REFLECTIONS ON PRACTICE

Implementation of Green Screen/Chroma Key Technology During Online Lectures

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ABSTRACT

The COVID-19 pandemic has caused an almost universal shift towards remote learning in higher education institutions, where teaching is now commonly conducted via synchronous or asynchronous online lectures. Much of the pedagogical literature indicates that the options for teachers to demonstrate non-verbal immediacy in online lectures and courses are severely limited, significantly reducing the opportunity to enhance students' motivation to learn. In this work, digital chroma key compositing (i.e. background removal) using a green screen and an open source software was adapted and implemented to livestream online lectures, where the lecturer's webcam-captured image was digitally inserted in real time onto the lecture slides on the main screen. This allowed the lecturer's non-verbal behaviours such as facial expressions, body posture, hand gestures, and eye contact to be obviously, immediately, and efficiently expressed. This enabled the lecturer to capture the students' attention more easily, as well as maintain a high level of student engagement with the lecture content during remote learning. The chroma key compositing method was implemented in the course GEH1032 "Modern Technology in Medicine and Healthcare" at the National University of Singapore (NUS), where a basic studio was set up in an office space using equipment that is affordable and accessible to individual faculty members. Comments on the use of this technology from both the mid-term and the end-of-term student feedback exercises were highly favourable. A set of detailed, step-by-step instructions regarding the instrumentation and software setup is provided in the Appendix as part of the supporting materials.

Keywords: Teacher immediacy, nonverbal immediacy, online lectures, green screen, chroma key.

INTRODUCTION

Due to the COVID-19 pandemic, almost all teaching and learning in NUS are now conducted remotely, where online platforms such as Zoom and Microsoft Teams are widely used to conduct lectures, tutorials, and group discussions. The conventional definition of many pedagogical concepts that are well defined for face-to-face instruction—classroom climate, learning environment, student engagement, and two-way feedback—must be adapted and redefined in this new normal of remote learning. In particular, teacher immediacy has long been shown to influence students' learning behaviour, enhance their motivation to learn, and demonstrate a positive correlation with both cognitive and affective learning (Andersen, 1979; Christophel, 1990; Brophy, 2004; Witt et al., 2004; LeFebvre & Allen, 2014). It represents a set of verbal and nonverbal behaviours teachers adopt that generate perceptions of psychological closeness between themselves and their students.

Verbal immediacy involves teacher behaviours such as addressing students by their names, incorporating humour, engaging in conversations with students, providing personal examples and experiences, demonstrating a willingness to provide and receive feedback, and more (Gorham, 1988). These behaviours may still be exhibited, albeit over online channels and media, during remote teaching. Indeed, much of the research on teacher immediacy in online courses mostly focus on the verbal, communication, social and written aspects of the courses to promote a sense of connectedness between students and the teacher, as well as between students and their classmates. Baker (2004) suggested various communication strategies to create a supportive learning environment, such as providing frequent reminders and updates, responding to emails or discussion threads in a timely manner, as well as having a regular presence in online discussion forums. Gunter's (2007) study identified instructional strategies that enhance immediacy in online courses, such as providing frequent feedback and praise, addressing students by name, using emoticons to generate a supportive tone in correspondences, as well as relating to students on a personal and professional level. Recently, Bello et al. (2020) explored students' perceptions of positive verbal and written characteristics that enhance teacher immediacy in online university classes, and proposed 13 immediacy-related methods that students perceived to be effective, such as providing personalised feedback and written encouragement, expressions of empathy, and more.

Non-verbal immediacy, on the other hand, involves using behavioural cues and body language such as posture, body movement, hand gestures, facial expression, eye contact, and more to encourage psychological affinity between students and the teacher (Andersen et al., 1979; Park et al., 2009; Hsu, 2010; Frymier et al., 2019; Liu, 2021). Such cues and body language are evident in how the teacher conducts face-to-face instruction in physical classrooms. Unfortunately, remote teaching has negated much of the opportunity for teachers to employ non-verbal behaviours. Indeed, much of the literature on teacher immediacy in online courses has mostly accepted that there is little opportunity to employ non-verbal behaviours. Trad et al. (2014) explicitly acknowledged that non-verbal immediacy behaviour may no longer be used to connect with students, while Schutt et al. (2009) stated that the "absence of a full range of nonverbal behaviors in typical distance education venues might contribute to increased psychological distance between students and their instructors" (p. 137).

In NUS, many of the synchronous and asynchronous platforms for online lectures relegate the webcam video of the lecturer's face to a small window at the edge of computer screen, entirely separate from the lecture presentation slides or notes that fill up the main bulk of the screen. Within the confines of this small window, it is difficult to effectively portray non-verbal behaviours to the students. In addition, it is likely that students' attention would mostly be on the lecture content being discussed on the main screen, and little attention is placed on the lecturer within the small window at one corner. With few, if any, visual interactions between the lecturer's webcam video and the lecture slides, the teacher's presence may be little felt or noted. This visual separation of the lecturer from the lecture content essentially dislodges the teacher from the classroom. Over time, students may gain a sense of dislocation between the lectures and the lecturer.

In this work, I propose the use of chroma key compositing with a green screen that allows for the projection of non-verbal behaviours which facilitate lecturer presence and immediacy, and promotes student engagement with the lecturer. This method digitally inserts the lecturer in front of the lecture content, simulating an actual classroom experience and in doing so, improves the lecturer's on-screen presence during remote learning. It is performed in real time using equipment that have in recent years become accessible, in terms of cost and availability, to not only institutions and corporation, but also individual educators.

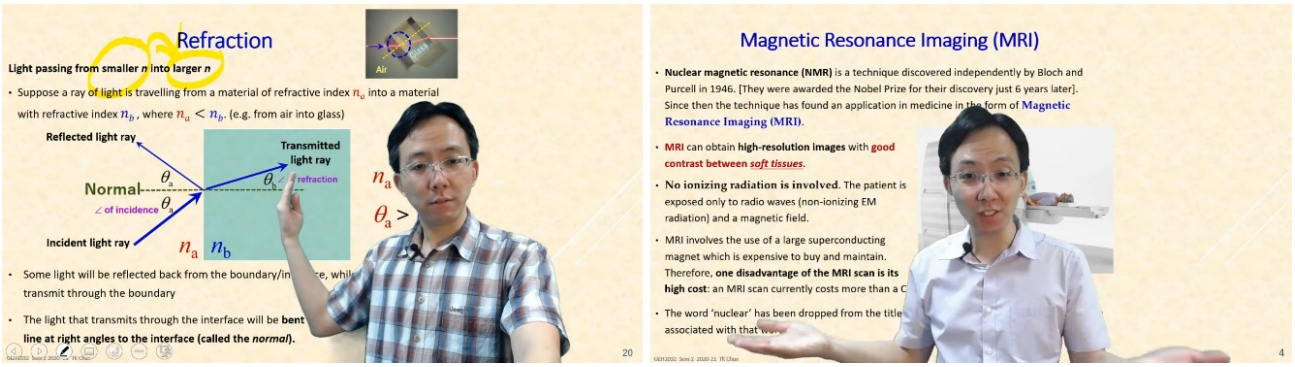

Figure 1. Screen captures of lectures conducted using chroma key compositing with a green screen.

In Figure 1, we have screen captures of actual online lectures conducted using the chroma key compositing method. The lecturer digitally appears in front of the lecture content and constitutes an integral part of the main screen. The non-verbal behaviours, such as facial expression, gestures, body posture and eye contact are clearly visible and conveyed with immediacy. This contrasts with Figure 2, which display a conventional online lecture layout, with the separate lecturer webcam window tucked away at a corner of the screen.

Figure 2. Screen capture of the conventional layout during online lectures.

REQUIRED EQUIPMENT AND PHYSICAL SETUP

The positioning of the physical equipment and software configuration setup require neither prior skill in studio videography nor deep knowledge of video broadcast software. The entire setup process may be completed within a single work day. A basic studio setup was established within an office space at the NUS Department of Physics (Figure 3).

Figure 3. Studio setup used in this work.

The essential pieces of equipment are listed as follows:

- Green screen
- High-performance laptop
- Two LED monitors
- High-definition webcam
- The open source Open Broadcaster Software (OBS) Studio software (free)

This method projects everything that is displayed on a single LED screen onto the chroma key composited image behind the lecturer. It is therefore compatible with almost any software used to produce the lecture content, including spreadsheets, video players, graphic design, PDF annotation software, and more. It will also work on most platforms that support live streaming, such as Zoom and Microsoft Teams.

Detailed instructions of the physical positioning of the studio setup, specifications of the major pieces of equipment, a set of step-by-step instructions for setting up the OBS software, and a short video segment sample of an actual lecture are provided as supporting material in the Appendix. The approximate cost of the entire set of equipment (priced at the time of printing) is $3,000 Singapore dollars, which should be a manageable sum for individual university academics.

ADVANTAGES AND LIMITATIONS

The chroma key compositing allows for a closer reproduction of lectures in a physical classroom. Non-verbal immediacy behaviours such as facial expression, hand gestures, body posture, and movements may now be used in an effective manner. The lecturer now forms a large and integral part of the lecture content and experience, allowing students to feel the lecturer's presence and remain engaged throughout the lecture sessions, reducing the sense of disconnect and isolation during remote learning. In addition, it allows the lecturer to physically point at and even interact with the lecture content and animations at different parts of the screen, allowing for improved clarity of explanations. This is particularly useful when complicated concepts are involved, and hand gestures may on many occasions replace onscreen pointers or cursors when highlighting different onscreen texts and objects. This method also allows lecturers to use eye contact to capture and hold students' attention.

However, there remains limitations to this approach. A major non-verbal behaviour which can be conveyed with immediacy is for the teacher to take centrestage in the classroom, without having any large obstacles between the teacher and students. This reduction of physical separation produces a sense of psychological closeness to students. This is impossible even with chroma key compositing, since everything remains confined to a two-dimensional computer screen. In addition, the lecturer may block part of the lecture content during the virtual session, which may at times be distracting to students. One method to reduce such blockage is to have the lecture content fill up only 80% of the screen area from the left, leaving a blank part of the screen on the right for the lecturer to co-exist with the lecture content without blocking any part of it. The blocking of the screen may in fact be used as a strategy to get students to focus their attention on the lecturer and not on the content. This is useful when the lecturer wishes to speak directly to them, or to emphasise certain points using eye contact. Lastly, the equipment cost and learning curve involved may serve as obstacles that prevent faculty members from adopting this method.

STUDENT FEEDBACK

The chroma key compositing was used in the course GEH1032 "Modern Technology in Medicine and Healthcare". Students were asked a series of five questions during the mid-term feedback exercise in Semester 2 of AY2020/21 to rate the efficacy of the chroma key technology using a 5-point Likert scale. There were 74 responses out of a class size of 157, indicating a 47.1% response rate.

Question 1**:** The green-screen technology allows the live lectures to be **more engaging** as compared to conventional Zoom lectures.

Question 2**:** The green-screen technology allows the live lectures to **more closely resemble the experience of physically attending an actual lecture** in a lecture theatre.

Question 3**:** The green-screen technology helps to **improve the clarity** of the live lectures during online lectures.

Question 4**:** The green-screen technology allows the lecturer to **capture your attention** more than conventional Zoom lectures.

Question 5**:** Overall, you **prefer the use of the green-screen technology during online lectures** in comparison to conventional Zoom lectures.

Table 1
Results of Questions 1 to 5 during the midterm feedback exercise for GEH1032

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	1.4%	0%	4.1%	24.3%	70.2%
2	1.4%	1.4%	8.1%	25.7%	63.4%
3	1.4%	0%	9.5%	29.7%	59.4%
4	1.4%	2.7%	1.4%	32.4%	62.1%
5	2.7%	1.4%	5.4%	21.6%	68.9%

The results in Table 1 indicate highly favourable responses, with close to 90% or more respondents indicating agreement or strong agreement for each question. This indicates that students perceive a significant improvement in (a) the level of engagement, (b) the resemblance to a physical classroom, (c) clarity of explanations, and (d) capturing of attention during online lectures when chroma key compositing is used.

DESCRIPTIVE COMMENTS

The following are selected descriptive comments that explicitly mentioned the chroma key compositing method. These were extracted from both the mid-term and end-of-term student feedback exercises in Semester 2 of AY2020/21 for GEH1032. Where the comments refer to the chroma key method, all were favourable; there were no unfavourable descriptive comments in either the mid-term or end-of-term feedback exercises.

> "The way the lecturer delivers the lecture is really good, it's easy to understand and the green screen allows for better capturing of attention."
>
> "The green screen technology is very effective, it really resembles a live face-to-face lecture."
>
> "Prof XX is very creative and tech–savvy where he uses green screen technology for teaching. This replicates the feel of being in a lecture theatre whereby we are able to follow the notes while being able to see which are the main parts he is pointing at."
>
> "He also went the extra mile to show himself gesturing to the slides in every lecture which makes lectures more engaging and overcomes the barrier of online lessons."

CONCLUSION

This work describes the implementation of chroma key compositing with the use of a green screen during online lectures. It digitally inserts the lecturer onto the screen in real time and allows the lecturer to directly interact with the lecture content, reproducing the physical classroom experience to greater effect for students. In addition, it allows for non-verbal cues to be effectively expressed with greater immediacy during remote learning and significantly improves the on-screen presence of the lecturer. Feedback from students were favourable, providing evidence on students' perceptions of the efficacy of this method. While there exist barriers to the adoption of this method, such as the equipment cost and the potentially steep learning curve involving software operation, this method remains accessible to individual faculty members.

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APPENDIX. SUPPORTING MATERIALS

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