Are virtual backgrounds during online learning distracting? An attention study using eye tracker technology

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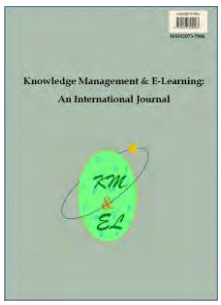

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Are virtual backgrounds during online learning distracting? An attention study using eye tracker technology

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Abstract: During and after the Covid-19 pandemic, online learning has gained popularity. Video conferencing, such as Zoom, has become the new normal in almost every individual's life. The purpose of this study is to observe the usage and preference of Virtual Background (VB) during video conferencing through a survey, whereas the effect of VB on attention during online meetings is evaluated through an eye tracker experiment. An online survey is conducted to observe the usage and preference of Indonesian users of Zoom in applied VB. Based on the most preferred VB, an eye tracker experiment was conducted to evaluate participants' attention during online learning using the three most preferred VB: office VB, plain background, and thematic VB. Eye tracker parameters, including Percentage of Participants who Fixated (PFF), Total Fixation Duration (TFD), Time to First Fixation (TFF), and Fixation Count (FC), were measured. The survey result showed that 71% of 303 respondents preferred their lecturers to use VB during Zoom meetings, 26% preferred office VB, 25% preferred plain VB, and 20% preferred thematic VB. An experiment that is conducted to evaluate attention during online meetings with three different VBs using an eye tracker shows that attention to lecture in plain VB is the best compared to other VBs, shown by the highest value of TFF and lowest TFD and FC. Implications of the result are discussed.

Keywords: Virtual background; Attention; Eye tracker; Online learning

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1. Introduction

Online learning, introduced in 1990, has proliferated due to information technology development. In addition, during and after the Covid-19 pandemic, online learning has gained popularity (Tomczyk et al., 2022; Ogbodoakum et al., 2022). During online learning, meeting via video conference applications such as ZoomTM has become the new normal in almost every individual's life (Goethe et al., 2021). Most research about online learning has been conducted on optimizing video conferencing and comparing its effectiveness in education with offline learning or face-to-face learning (for example, Widyanti et al., 2020). Features have also been developed (e.g., active talk indicator, screen annotation and sharing, and meeting recording) and added to video conferencing applications to make online classes more exciting and compelling. Effectiveness and attractiveness in video conferencing are crucial since the best possible pedagogy in learning is through interactive learning experiences (Sweetman, 2021). Therefore, student engagement is emphasized through providing highly interactive virtual learning sessions (Ocak & Karakuş, 2022).

One of the widely used features in video conferencing is the virtual background (VB). VB usage is supported by the fact that it elevates the level of attractiveness (Russel, 2021). Online learning sessions' attractiveness will help reduce fatigue during online learning (Bailenson, 2021). In addition, the possibility of choosing a VB can prevent other online learning participants from seeing the actual setting from which one is attending the online session. The motivations for hiding the actual environment might be protecting privacy, lacking a suitable work area, or personal preferences.

VB can be used by both teachers and students in online learning environments. For the purpose of uniformity, online meeting participants were frequently required to use virtual backgrounds provided by the meeting organizer. Aknuranda et al. (2021) discovered that users of online meeting programs acknowledged that identical virtual backgrounds could provide beneficial effects, such as a sense of community. Other reasons for using VB include being concerned about the possibility of the surrounding people/environment appearing in the background and having a weak internet connection (Castelli & Sarvary, 2021).

Meanwhile, from the instructor's side, Merkt et al. (2019) contrasted the learning outcomes of seeing a video taken against a white wall background with an authentic setting represented by a greenhouse. They hypothesized that the video's setting would affect the learning outcomes – however, no differences were observed between the two circumstances. Kerckhoffs (2022) examined the effect of video background on learning

outcomes by comparing homemade instructional videos with three distinct virtual backgrounds: neutral background, topic-relevant background (i.e., a background that was related to the learning topic), and off-topic background (i.e., a background that was not relevant with the topic of learning). In comparison to other VBs, the neutral background produced the best learning outcomes.

Aside from learning outcomes, another essential aspect of VB is attention, as it is hypothesized that the use of VB reduces attention during online learning since VB can become a distraction if it is not suitable and inappropriate (Goethe et al., 2021). According to research, student attention – defined as the behavior of selectively concentrating on a discrete aspect of information while ignoring other perceptible information (Johnson & Proctor, 2004) is an integral component of successful learning because sustained attention improves learning performances (Chen & Wang, 2017; Ding & Lyu, 2021; Kuo et al., 2017).

Measuring attention is quite challenging. Suttidee (2020) examines attention measurements during online learning through behavior observation signals, self-reporting methods, and questionnaires. While self-reporting surveys and questionnaires can be unreliable (Romero, 2014), behavior observation signals can be difficult to evaluate since they are not easily observable and require specialized skills to interpret the results (Macaulay & Edmonds, 2004). Electroencephalograph, Galvanic Skin Response (Widyanti et al., 2017a), and eye tracker (Widyanti et al., 2017b) can all be utilized to assess behavior signals.

Eye tracking sensors capture data regarding the location and duration of an eye fixation inside a particular area. It is a common method for observing the allocation of visual attention (Carter & Luke, 2020) through the eye-mind link (Reichle and Reingold, 2013). The eye structure limits high-acuity vision to a small portion of the visual field called the fovea and the mind instructs the eyes to move the fovea in order to highlight the stimuli of the task that the human is currently thinking about or processing. The eye-mind hypothesis (Just & Carpenter, 1980), which explains that there is a close relationship between the direction of the human gaze and the focus of attention, proposes that what people fixate on has a close relationship with what they process.

Multiple eye tracker metrics can be assessed. Bergstrom and Schall (2014) outlined many eye tracker metrics generated from fixation, including Participants Who Fixated (PPF), Time to First Fixation (TFF), Total Fixation Duration (TFD), and Fixation Count (FC). PPF estimates the proportion of participants who focused on a target or Area of Interest (AoI; defined specific regions that are selected in a scene). Low PPF towards a region implies that the region is not adequately highlighted (Poole & Ball, 2006). Time to First Fixation (TFF) assesses how long it takes participants to first fixate on a target or area of interest. Smaller TFF indicates that a location is more interesting (Byrne et al., 1999). Total Fixation Duration (TFD) calculates the entire duration of fixation on the target or AoI by a participant. Longer TFD indicates greater interest in a certain region (Poole & Ball, 2006). Fixation Count (FC) quantifies the number of times a participant fixated on the target or AoI. A region with a greater number of FCs attracts the participants' interest (Bergstorm & Schall, 2014).

In addition to fixation measures, there is a heat map that illustrates the participant's focus on a specific portion of the display. It depicts in various colors the number of fixations or duration of fixations on a target or AoI (Bergstrom & Schall, 2014; Joseph and Marugesh, 2020). Red denotes a comparatively high number of fixations or duration of

fixations, green shows a relatively low number of fixations or duration of fixations, and colorless indicates that participants are not fixated on the area.

Lastly, the scan path, which is a combination of fixation and saccade displays the fixation sequence (Poole & Ball, 2006), from one AoI to another AoI (Jacob & Karn, 2003). According to Goldberg and Kotval (2003), the scan path can be subjectively assessed to determine the level of visual search complexity on the display. A gaze plot is a map that depicts the sequence of fixation movements on a visual display (Joseph & Marugesh, 2020), where more steps to finish a task indicate a greater cognitive load.

Numerous studies have applied eye tracking to investigate attention. The majority of studies have been conducted on online shopping (Ho, 2014; Hwang & Lee, 2018). There is also various research on the application of eye tracking in online education. For instance, Wang et al. (2020) monitored visual attention to the instructor in an online video and discovered that the majority of participants exhibited a good attitude toward the instructor, who also garnered a significant amount of overt visual attention. Stickler and Shi (2015) examined the attentiveness of students during synchronous online language education using eye-tracking technologies. Another study by Liu and Zhu (2012) uses an eye tracker to analyze and examine the functionality and usability of an online learning course's homepage.

Considering the significance of VB in video conferencing for enhancing the attractiveness of and concealing the actual surroundings during online learning, it is essential to observe aspects that facilitate or impede the usage of VB during online learning. The effect of the use of virtual background on learners' focus during online education also needs to be investigated. Consequently, the goal of this study is to examine the use of VB in the Indonesian sample via a survey and to investigate the influence of various VB on attention during online learning through an eye-tracking experiment.

2. Method

2.1. Participants

2.1.1. Participants of the online survey on VB preference

303 undergraduate students from Institut Teknologi Bandung (ITB; 148 men, 155 females) participated in this study willingly by responding to an online questionnaire. Random sampling is applied to get the respondents. Each respondent has used Zoom as an online learning platform in ITB. The number 303 represents the total of 23,848 ITB students. With a confidence level of 95% and an error margin of 10%, 96 respondents are required. The calculation of sample size was carried out according to Berenson et al. (2018) as follows:

$$n_0 = \frac{Z^2 \pi (1 - \pi)}{e^2}$$

$$n = \frac{n_0 N}{n_0 + (N - 1)}$$

Where n_0: Sample size without considering the finite population correction factor; n: Sample size using the finite population correction factor; Z: Z statistic value with the confidence level; π: Estimation of the population proportion; e: Margin of error from population estimation; N: Number of population

2.1.2. Participants in eye tracker experiment

Twenty participants (Mean age = 21.4 years, SD = 0.6 years, *N* males = 7, *N* females = 13) voluntarily participated in an eye tracker experiment (Mean age = 21.4 years, SD = 0.6 years). Participants are recruited using purposive sampling. To be included as participants, they must be active ITB undergraduate students with prior experience utilizing the Zoom platform for online learning at ITB. All participants filled out an informed consent form. The experiment's participants are a subset of those who responded to the previous online survey on VB preference.

2.2. Procedures

2.2.1. Online questionnaire

The online survey respondents were given a self-developed questionnaire that included demographic data questions (i.e., gender and educational background) as well as questions regarding their preference for virtual background used by their lecturers during online learning, the most frequently used virtual backgrounds, and whether or not they have ever been distracted by virtual backgrounds during online learning. The response answer was in the form of several options in which the respondents could choose among the answers. In addition, a blank space is also provided so that if the respondents wanted to give answers different from the available options, they could write them down.

2.2.2. Experiment

The experiment and its procedure follow the Declaration of Helsinki 7th edition by the World Medical Association (2013).

2.2.3. Stimuli

The three most preferred virtual backgrounds (VB) used by the lecturer (as a result of the online questionnaire) are used as stimuli: plain background, thematic background, and office background. The VB is applied in a video of Zoom online learning, with the speaker at the center of the Zoom. No slide is presented, since during pilot testing, it was determined that the usage of slides would draw the participants' attention more than the speaker and the background. Another reason is that it is typical practice in online education in which no slide is displayed during discussion sessions.

The participants were instructed to see a two-minute video of Zoom online learning with four distinct visual backgrounds, including a plain background, an office setting, and two thematic backgrounds (i.e., ITB-familiar thematic background, and a totally new thematic- unfamiliar background). Differentiating thematic background based on familiarity is required because the unfamiliar background is hypothesized to attract more attention in comparison with the familiar background. There was a three-minute break between each video. The order of the videos for each participant was randomized using the balanced Latin square method. The videos were displayed on a 24-inch monitor.

Participants' attentions were evaluated using the Eyegaze Edge eye tracker. The videos were presented on a Mac mini 6.2 computer (24-inch Asus VE248 monitor, display

resolution of 1920 × 1080, set to about 40-60 cm in front of the participant) via NYAN 2.0 x86 software. The same software was used to analyze the eye-tracking data.

2.2.3. Measures

Two Areas of Interests (AoI) were defined using the NYAN 2.0 software: AoI which covers the lecturer and AoI which covers the virtual background. Several eye fixation metrics were assessed from the eye tracker data including the Percentage of Person who Fixated (PFF), Total Fixation Duration (TFD), Time to First Fixation (TFF), and Fixation Count (FC). In addition to eye fixation metrics, the gaze plot and heat map of the participants were analyzed qualitatively.

3. Data analysis

The lecturers' and students' VB preferences are reported in descriptive statistics. Eye tracker data are normalized by scaling them to the duration of the video and analyzed using statistical interference. Later, the data are examined for normalcy before selecting which multiple significance tests to employ. The non-normally distributed data were evaluated using the Kruskal-Wallis H test, followed by the Bonferroni post hoc test. The normally distributed data were examined using ANOVA, followed by Fisher's LSD post hoc test.

4. Result

4.1. Result of online survey on preferences of VB

The results of the online survey on preferences for VB in Zoom meetings indicate that 71% of 303 respondents prefer their lecturers to use VB during Zoom meetings as VB can reduce distractions caused by an unconducive environment and can make lecturers appear tidy and professional. While the remaining 29% would prefer that their professors refrain from using VB since it can obscure the professor's face, and some believe it has no impact on the learning process. Table 1 illustrates the VB usage preference. The most preferred VB among respondents is office VB, while the most used VB among lecturers is thematic VB.

Table 1
VB usage preference

	The most preferred VB by respondents	The most used VB by lecturers
Office VB	26%	20%
Plain VB	25%	10%
Thematic VB	20%	43%

4.2. Result of the experiment using eye tracker

The result of the eye tracker fixation metric with normalization can be seen in Table 2. The data were normalized using the simple feature scaling method.

Table 2
Parameter of eye tracker experiment – fixation

Virtual background	Area of interest	Percentage of participants who fixated (%)	Time to first fixation (s)	Total fixation duration (s)	Fixation count
Unfamiliar thematic VB	VB	100	2.869	31.164	106.783
	Lecturer	100	1.078	88.203	130.806
	Outside AOIs	90	18.416	4.531	15.579
ITB-familiar thematic VB	VB	100	2.659	41.016	142.901
	Lecturer	100	1.145	78.517	123.263
	Outside AOIs	100	30.080	3.292	12.230
Office VB	VB	100	2.844	17.270	52.150
	Lecturer	100	.583	103.846	173.700
	Outside AOIs	85	29.275	3.500	10.294
Plain VB	VB	100	22.229	5.952*	19.100
	Lecturer	100	.676	113.142	171.000
	Outside AOIs	95	27.905	4.359	13.263

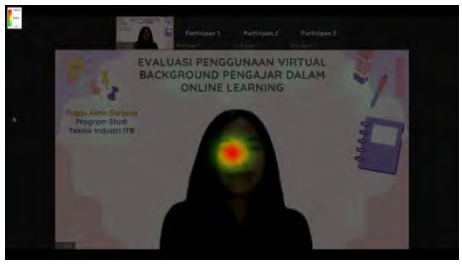
Note. * $p < .05$

As predicted, participants were more fixated on the VB and the lecturer than on AOIs outside the VB, as indicated by the low TFD values for AOIs outside the VBs in all VBs. Not all individuals fixated on areas outside the AOIs, as evidenced by the percentage of participants who did so was less than 100 percent. The exception was plain VB, which TFF was comparable to that of AOIs outside the AOI. In every VB, participants tended to fixate initially on the lecturer area rather than the VB region, as reflected by the marked decrease of TFF in the lecturer area compared to the VB area. TFF of simple VB was much longer than that of other VBs, whereas office VB exhibited a similar trend, but the difference was not statistically significant. This suggested that the plain VB received the least amount of attention compared to the other VBs ($H(3) = 11.217$, $p = .01$). Comparing TFF among lecturer's areas revealed that the Office VB had the lowest TFF, while the difference was not statistically significant ($p > .05$).

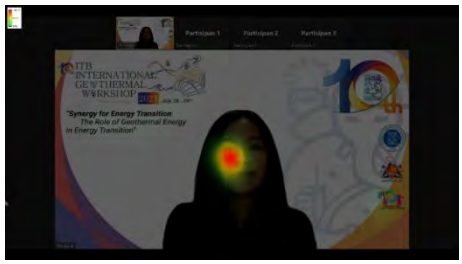
Total Fixation Duration (TFD) data indicated that the TFD for all VB was longer in the lecturer area compared to the VB area. This confirmed our expectation that the lecturer region would receive more attention than the VB area. Although not significantly different ($p > .05$), the longest fixation duration in the lecturer area was on the plain VB. This, together with the fact that the plain VB had the smallest TFD among the other VB ($H(3) = 44.466$, $p < .05$), showed that the plain VB was the least distracting.

As anticipated, the total fixation count (TFC) in the VB region is lower than in the lecturer area, indicating that the lecturer area receives more attention than the VB area. Total fixation count (FC) in ITB-familiar thematic VB is an exception; the FC in the VB area was more than in the lecturer area. Despite the absence of a statistically significant difference ($p > .05$), the lowest fixation count in the VB area was seen on plain VB ($H(3) = 52{,}171$, $p < .01$).

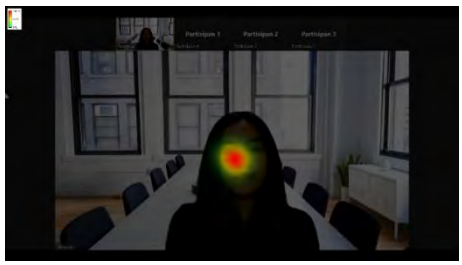
Other measures of eye tracker are heat map and gaze path. The example of a heatmap display from one participant can be seen in Fig. 1, while the example of the gaze path can be seen in Fig. 2.



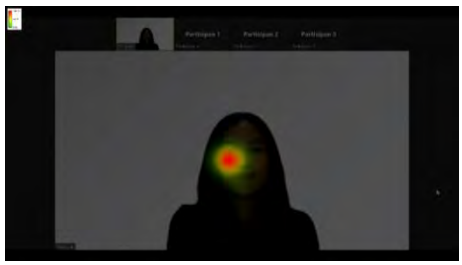
(a) Heat map of unfamiliar thematic VB



(b) Heat map of ITB-familiar thematic VB



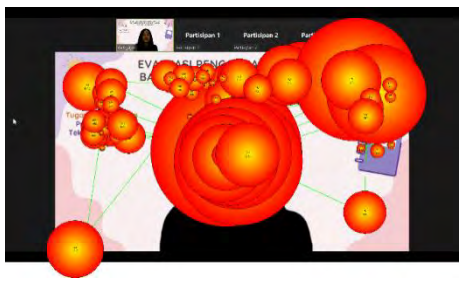
(c) Heat map of office VB



(d) Heat map of plain VB

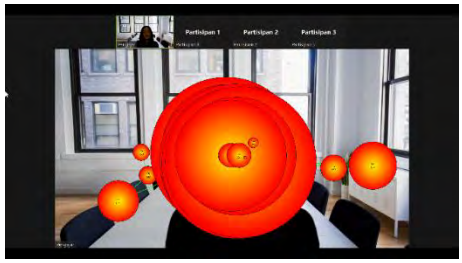
Fig. 1. Heatmap of eye tracker as a function of VB

Other participants' heat maps display nearly identical results. All participants prefer to look at the lecturer's face, as shown by the similarity of the heat maps across VB. However, participants were also attracted to fixate on the VB's letters and illustrations.

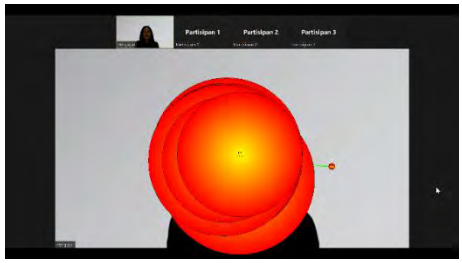


(a) Gaze path of unfamiliar thematic VB

(b) Gaze path of ITB-familiar thematic VB



(c) Gaze path of office VB



(d) Gaze path of plain VB

Fig. 2. Gaze path as a function of VB

5. Discussion

The purpose of this study is to analyze the use of VB in Indonesia by means of a survey and to examine the effect of VB on attention during online learning via an eye-tracking experiment. The majority of respondents preferred VB due to its aesthetics, whereas those who opted not to use VB saw it as distracting. The lecturers also primarily utilized VB. The respondents' preferred VB was the plain background. Using an eye tracker, the experiment demonstrated that VB is distracting. However, the plain VB created the least amount of distraction.

In relation to VB preferences, the result of this study contradicts the finding of Goethe et al. (2021) which found that among Norwegian students, VB is not strongly preferred by students in a learning context – few students change their background in digital lectures and some attention is paid to the use of backgrounds by lecturers and fellow students. This partially explains why the usage of background is regarded to be distracting. However, similar results were obtained for the reasons why VB is preferred by students. Goethe et al. (2021) discovered that VB is used to conceal bystanders or messy/inappropriate settings. On the other side, this study is consistent with a study by Bailenson (2021) in which zoom fatigue (defined as feeling fatigued from being on videoconferences all day) is attributed, in part, to heightened self-evaluation caused by staring at one's own video. Therefore, the application of VB may be chosen because it shifts the emphasis away from oneself. It can be stated that the use of VB in online learning is subjective and dependent on the user's preference.

The decreased focus when utilizing VBs is consistent with the distraction theory (Merkt et al., 2019). According to this hypothesis, the background of a video could be distracting. The Cognitive Theory of Multimedia Learning (CTML; Mayer, 2009, 2014) can explain this phenomenon. CTML describes how individuals learn from multimedia presentations. The CTML is based on three assumptions: people process incoming verbal and visual information through two separate channels (the dual-channel assumption; Baddeley, 1999); the amount of information each channel can process at once is limited (the limited-capacity assumption) (Baddeley, 1999; Sweller et al., 2011); and people must actively attend to useful information in order to transfer it into working memory (the active processing assumption, Mayer, 2009). In accordance with the results of the heat map, VBs that consist of letters and images may distract participants by attracting their attention.

As anticipated, plain VB is the least distracting compared to other VB. The absence of additional information or letters in the VB allowed the audience to focus solely on the presenter. The principle of learning and familiarity can explain why the new and unfamiliar thematic background was the most distracting visual background. In the literature, conclusions regarding the relationship between attention and familiarity are inconsistent. Both something familiar (Flowers et al., 1981) and something unfamiliar (Johnston et al., 1990) draw attention. Subjective perception is believed to have a significant impact, which may contribute to the subjective reality of individuals (Grabot & Kayser, 2020).

Using an eye tracker to measure attention has proven to be an effective technique for gaining insight into perceptual processing, particularly attention during learning (Mayer, 2010). Heat maps, which reflect people's gaze fixations by illustrating the extent of occurrences in which the eye remains steady for a specific amount of time (Holmqvist et al., 2011), are closely associated with their focus of attention. In addition, Mu et al. (2019) observed that there is no significant variation in attention preference across students with

different visual-verbal learning styles, indicating that short instructional videos can draw students' attention during the online learning process.

There was consistency between the survey and experiment results. The majority of students surveyed indicated that VB was preferable and not distracting. The results of the experiment corroborated the survey finding that the majority of students devoted greater attention to lecturers than to VBs in VB situations, in particular in plain VB.

This study has several limitations. First, the participants are limited to university students having a background in engineering. Expanding the respondent group beyond engineering students to include students from other universities may yield more generalizable findings. Second, the only VBs employed in this experiment were plain, thematic, and office-related VBs. Additional research on the evaluation of attention using different types of VBs (e.g., natural environment VBs, animated VBs) is required to provide additional information. Third, an eye tracker was utilized to evaluate attention. For a comprehensive examination, it is proposed that attention be evaluated using alternative methods, such as self-reported questionnaires or other objective devices, such as brain wave measurement using electroencephalography. In addition, evaluating student outcomes as supplementary data for attention will expand the analysis. Besides the limitation, this study is the first to examine the use of VB in online learning from the perspective of attention.

In conclusion, for practical implication, educators should be aware that their choice for a background in an instructional video, and possibly also during an online course, has an effect on their students' attention. Whereas some prefer to use VB as it is perceived as attractive, some perceive VB as distracting. It should be underlined that when choosing the VB, the least distracting VB is the plain background.

Although the epidemic has become endemic, online learning and hybrid learning (which combines online and offline learning) have become the standard in educational settings. Consequently, the use of internet platforms like Zoom may continue. Because VB is extensively used in Zoom platforms, it is particularly crucial for future research to investigate VB from a variety of perspectives, such as psychological and leisure feelings during Zoom time utilizing VB.

Author Statement

The authors declare that there is no conflict of interest.

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