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Electronic Display Devices: A Study on Screen Display towards the Health Issues among Malaysian University Students

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Abstract

Excessive exposure to electronic technology has been linked to adverse physical, social, and mental health. Questions have been raised about the impact of electronic devices with a drastic shift to online learning in education. The drastic surge of exposure duration, and the explosively accelerated electronic technology transformation may have idiosyncratic health impact. This article aimed to investigate the impact of electronic technology in the education setting using a mixed-method approach: laboratory-based exploration and an online survey during the unprecedented COVID-19 pandemic. First, we compared the illumination profile of the screen display in comparison to traditional hardcopy materials. The luminance and spectrum profiles of smartphones and laptops were studied using the 2D Color Analyzer CA-2500 and illuminance spectrophotometer CL-500A. Second, we surveyed the digital usage profile of university students from six different universities to gather information on the total hour of daily electronic engagement and the incidence of digital eye strain. The surface luminance for smartphone is 94.76 ± 11.46 cd/m^2) and laptop (250.28 ± 22.88 cd/m^2). The surface luminance of smartphones rises by 7% in comparison to hardcopy surfaces. The surface luminance of laptops upsurges by 203% in comparison to hardcopy surfaces. The electronic engagement time of university students is about 12.80 ± 3.47 hours per day. Digital eye strain is approximately 22.15%. Self-luminosity screen displays from electronic devices emitted more luminance compared to the hardcopy materials. The electronic surface has low luminance uniformity compared to the hardcopy surface. University students exhibit high electronic usage patterns and are susceptible to digital eye strain. The long-term accumulative effects of the high illuminance profile, electronic engagement inclination and uprising digital eye strain from our cross-section study require further investigation.

Keywords: electronic technology, electronic display devices, digital eye strain, luminance and spectrum profile

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INTRODUCTION

The industrial revolution has caused substantial lifestyle changes over the years (Vaidya, Ambad, & Bhosle, 2018). Electronic technology has become inseparable from our daily life. Humans have a long history of electronic exposure, from the analogue technology of television to the electronic technology of mobile devices. The display technology changed from the bulky size, fixed setting, to small and portable (Vaidya et al., 2018). Increasing electronic usage raises public concern about the long-term effect on health (Hale L, 2015; Linda Harasim, 2000; Mustafaoğlu, Zirek, Yasacı, & Razak Özdinçler, 2018; Ostrin, 2019; Sheppard & Wolffsohn, 2018; Small et al., 2020). Many studies have concluded the negative impact of excessive exposure to the Internet and electronic technology on physical, mental, and social health.

Electronic devices have become part of our lifestyle, not just for communications but also as a platform for getting information, socializing, entertainment, and performing banking activities (Bassett, John, Conger, Fitzhugh, & Coe, 2015; LeBourgeois et al., 2017; Odeh & Hussein, 2016). The use of a desktop, laptop, tablet computers, smartphones, and electronic reading devices has become ubiquitous. The Internet has become an essential tool for learning (Akbar, 2016; Broadbent & Poon, 2015; Linda Harasim, 2000). Increased exposure to electronic devices is likely to occur as these devices become more common at all educational system levels. Younger generations are more likely to experience electronic device exposures in their education system (Bassett et al., 2015; Odeh & Hussein, 2016; Rodrigues, Almeida, Figueiredo, & Lopes, 2019). The learning environment shifts from face-to-face, blended learning, to open and distance learning alongside electronic technologies (Mpungose, 2020). From traditional to digitalization in education, this evolution showed a shift from hardcopy to electronic type-based learning. The demand for vision between hardcopy and electronic type-based learning is incomparable. Electronic book readers have been reported to exhibit higher visual fatigue with respect to the paper book (S Benedetto, Carbone, Drai-Zerbib, Pedrotti, & Baccino, 2014; Simone Benedetto, Drai-Zerbib, Pedrotti, Tissier, & Baccino, 2013). Questions have been raised about the overuse of electronic devices that may have negative indications with a rapid shift to online learning in education among youth due to the unprecedented COVID-19 pandemic (Ganne, Najeeb, Chaitanya, Sharma, & Krishnappa, 2021; Jayadev, Sarbajna, & Vinekar, 2020). The substantial change of time exposure, closer working distance, and touchscreen technology may have a short-term and long-term impact. This article aimed to investigate the effects of electronic technology in education settings using a mixed-method approach: laboratory-based exploration and online survey about electronic exposure among university students.

RESEARCH METHODOLOGY

Ethical approval was obtained from the UITM Research Ethics Committee [600-TNCPI (5/1/6) REC/04/2021 (UG/MR/300)]. A mixed-method approach was employed in the exploration. The laboratory-based exploration was designed to assess the luminance and spectrum profile from the

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electronic display devices. The data provided objective dimension of the devices. The online survey data offered health information linked to electronic exposure among university students.

The experimental setup to evaluate the luminance and spectrum profile of electronic display devices (smartphone and laptop) is presented in Figure 1. The workstation was in a neutral grey colour to minimize the colour interference. Each electronic device was positioned on an adjustable reading stand on the workstation table so that the surface was perpendicular to the point of incidence of the measuring apparatus. The viewing distance of 40 cm was standardized. The luminance was measured using the 2D Color Analyzer CA-2500 (Company: Konica Minolta, Japan). The device was securely stationed on a tripod and set 40 cm away from the display for a hypothetical human viewer. The wide lens was focused accordingly to simulate the human field of view. Snapshots were taken of the scene through the CA-2500 camera. The spectrum profile was examined by illuminance spectrophotometer CL-500A (Company: Konica Minolta, Japan) at the centre of the screen display and paper view as reference point. The reference point was to ensure that the same point was used in both settings to rule out systematic measurement errors. We employed the measurements using the spot measurement function of the 5 × 5 grid points shown in Figure 2. All measurements were taken in CMB-2540 light booth (64 cm x 102 cm x 64 cm). Every spot was automated and double-checked for analysis. The information of the testing surfaces and experimental setups in the investigation is listed in Table 1. A hardcopy paper was used as the control for comparison.

An online survey was conducted to gather information on electronic engagement profiles. The survey instrument used in this study was modified and simplified from the Lifestyle Study in Youth questionnaire (Chen, Rosli, & Hovis, 2020). The survey recorded the total hours of sleep and electronic devices usage per day for each respondent. The survey questions also covered vision problems at far, vision problems at near, light sensitivity, dry eye syndrome, ocular pain, visual fatigue and headache. The data collection was conducted using the Google Forms platform in May-June 2021. Using Cochran's Sample Size Formula with a confidence interval of 95% and a margin of error of 5%, the recommended sample size was 150 respondents. The inclusion criteria were local undergraduate degree students. Certificate, diploma, and postgraduate students were excluded. We disseminated online questionnaires to three public universities and three private universities.

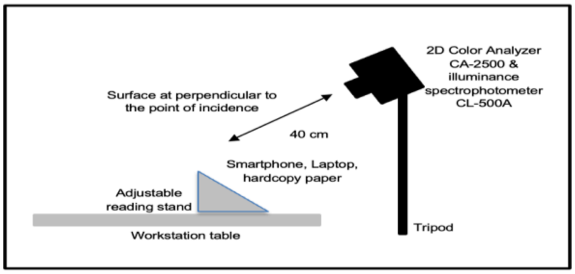

Figure 1: Experimental setup of luminance and spectrum profile investigation

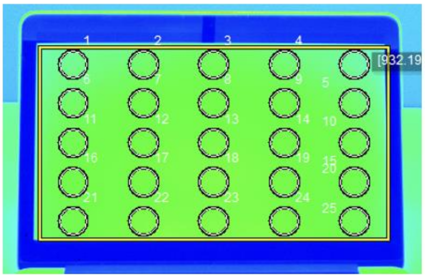

Figure 2: The 5 x 5 grid points for measurement of electronic and hardcopy display

Table 1: The information of the testing surfaces and experimental setups in the investigation

Testing surfaces	Descriptions of experimental setups
Smartphone	○ iPhone 54.00-inch touchscreen display with a resolution of 640x1136 pixels at a pixel density of 326 pixels per inch (ppi) and an aspect ratio of 16:9. ○ Social media task display – Standard Facebook interface
Laptop	○ MacBook Pro Retina Display 13.3 inch, with a resolution 2560 x 1600 pixels ○ Social media task display – Standard Facebook interface
Hardcopy paper	○ As control ○ Social media task display – Standard Facebook interface, replaced with printed out on hardcopy paper. The hardcopy surface resembled the image on the respective electronic device by print screen and then printed with a colour printer on A4 white paper. ○ superimpose on the respective turn-off electronic display to maintain the same fixation gaze

Descriptive data were generated for all variables. Descriptive statistics were used to summarize data in the form of simple quantitative measures such as means and standard deviations.

FINDINGS AND DISCUSSION

Information on spectrum profile and surface luminance of electronic devices are listed in Table 2. The surface luminance for smartphone and laptop is 94.76 ± 11.46 cd/m^2 and 250.28 ± 22.88 cd/m^2, respectively. The surface luminance for hardcopy paper surfaces is similar for smartphones (88.64 ± 2.66 cd/m^2) and laptops (82.63 ± 4.46 cd/m^2) despite the larger surface area of laptops. The surface luminance of smartphones rises by 7% in comparison to hardcopy surfaces. The surface luminance of laptops upsurges by 203% compared to hardcopy surfaces as control. Self-luminosity screen displays emitted more luminance compared to the hardcopy surface. In addition, the electronic surface has low

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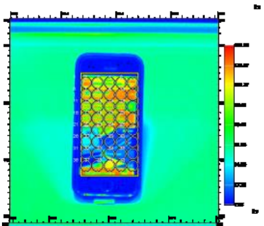
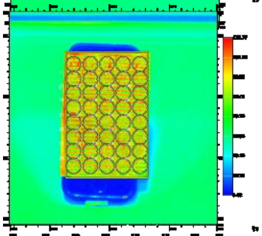
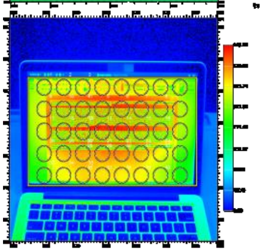
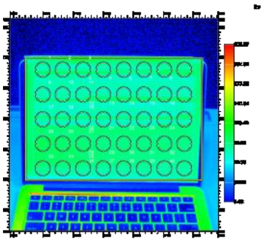
luminance uniformity compared with the hardcopy surface. A bright light has been identified as a migraine trigger (Albilali & Dilli, 2018). Recent evidence shows significant variations in circadian photosensitivity due to artificial light exposure (Chellappa, 2021).

Table 2: Information on spectrum profile and surface luminance of electronic devices

Types	Spectrum Profile	Surface luminance (cd/m^2)	
Smartphone (Turn on) Standard Facebook interface on the electronic surface		Mean Standard Deviation Minimum Maximum Uniformity=100*Min/Max	94.76 11.46 60.28 118.07 51.05
Smartphone (Turn off) Standard Facebook interface – replaced with printed out on hardcopy paper		Mean Standard Deviation Minimum Maximum Uniformity=100*Min/Max	88.64 2.66 95.11 80.13 84.25
Laptop (Turn on) Standard Facebook interface on the electronic surface		Mean Standard Deviation Minimum Maximum Uniformity=100*Min/Max	250.28 22.88 277.92 176.21 63.4
Laptop (Turn off) Standard Facebook interface – replaced with printed out on hardcopy paper		Mean Standard Deviation Minimum Maximum Uniformity=100*Min/Max	82.63 4.46 96.32 77.2 80.15

There has been a resurgence of research to address the complications associated with electronic devices dominating lifestyle in this digital era. Spending time on electronics is going uptrend over the years, contributing to a sedentary lifestyle, extra demand for vision, sleep and psychological problems. Inappropriate use of electronic devices in terms of content, duration, frequency, and posture may pose a variety of health risks, including vision problems, musculoskeletal problems, mental health issues, obesity, and inadequate sleep quality (Bauer et al., 2018; Gong et al., 2012; Knaeps, Bourgois, Charlier, Mertens, & Lefevre, 2017; Li et al., 2016; Small et al., 2020). The electronic engagement time is alarming in our university student samples. The average total hour for electronic engagement is about 12.80 ± 3.47 hours per day. Nowadays, most adults and children work with electronic devices for significant amounts of time, and many activities can be carried out with electronic devices (Rosenfield, Howarth, Sheedy, & Crossland, 2012). Electronic display activities, either for leisure or work, contribute to the increment of sedentary time (Battersby, Haysom, Kroll, & Tawodzera, 2015; Rowlands, 2017). In developed countries, electronic devices' usage is almost similar as in our study, approximately 10 to 12 hours/day from the stationary display device to a mobile display device like a smartphone, tablet or laptop (Blehm, Vishnu, Khattak, Mitra, & Yee, 2005; Cremers et al., 2021; Yan, Hu, Chen, & Lu, 2008).

There have been numerous health concerns associated with electronic usage. Ocular problems are among the most common complaint (Chu, Rosenfield, & Portello, 2014; Rosenfield, 2011; Rosenfield, Bababekova, & Portello, 2012; Rosenfield, Howarth, et al., 2012; Rosenfield, Jahan, Nunez, & Chan, 2015; Rosenfield, Li, & Kirsch, 2020). With the increasing amount of time in front of electronic devices; prolonged exposure to electronic screen can induce ocular discomfort that commonly referred to as digital eye strain. Recently, studies have demonstrated a high prevalence of visual discomfort in electronic devices users (Scheiman, 1996; Schlote, Kadner, & Freudenthaler, 2004; Thomson, 1998). Digital eye strain has been associated with the 'new norm' lifestyle during the COVID-19 pandemic (Bhattacharya, Saleem, & Singh, 2020; Ganne et al., 2021; Jayadev et al., 2020). Nearly one quarter (22.15%) of our sample suffer from digital eye strain. Interestingly, our findings of the vision problems at far (44.97%) are alarmingly high. The vision problem at near is only about 20.13%. Excessive electronic exposure is associated with light sensitivity, dry eye, fatigue and headache. Chronic interaction with electronic devices might lead to eye-related symptoms and other physical and mental health concerns (Clark, Yang, Khaderi, & Moshfeghi, 2018; Sheppard & Wolffsohn, 2018; Small et al., 2020). The visual symptom is the crucial indicator to predict any cumulative or subsequence effect due to any risk factor (Chen et al., 2020; Jaiswal et al., 2019).

Another negative impact of electronic technology overuse is sleep interference due to the blue light emitted from the electronic screens (Chellappa, 2021; Ostrin, 2019). We found that our university students have less sleeping time than the recommendation of eight hours. The average total sleeping hour in our sample is about 6.21 ± 1.44 hours per day. It is likely, therefore, that it may have long-term health consequences. The effects of blue light can suppress melatonin and disturb the sleep-wake cycle (Bauer et al., 2018; Ostrin, 2019).

SUMMARY

This study contributes to research on the electronic impact in the education ecosystem by presenting electronic engagement profiles and illuminance profiles related to electronic exposure. One of the issues that emerge from these findings is that the luminance surface may contribute to the electronic stress in addition to the blue light hazard (Dain, 2020; Lin, Gerratt, Bassi, & Apte, 2017). Self-luminosity screen displays emitted more luminance compared to the hardcopy surface. High electronic engagement time, evident digital eye strain and reduced sleeping hours raised a red flag about the potential health concerns in the long term. Further studies, which take these variables into account, will need to be undertaken. The luminance surface is an essential issue for future research. The long-term accumulative effect of this high illuminance profile, electronic engagement inclination, and uprising digital eye strain from our cross-section study design requires further investigation. These findings are of general use to the vision health care plan for university students.

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