A QUALITATIVE USER EXPERIENCE STUDY ON DARK MODE ADOPTION AND USABILITY CHALLENGES

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# Abstract

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# Introduction

*This chapter will first showcase the background and context, followed by the research problem, aims, objectives, questions, significance, and limitations.*

## Background

Dark mode can be understood as a display mode on a digital screen with a dark-colored background, while the text and other components on the screen are displayed in brighter colors. On the other hand, light mode displays a bright-colored background, like white. Figure 1 (Budiu, 2020) shows a visual comparison of those two display modes on iPhone’s iOS 13.

A screenshot of a phone

Description automatically generated

Figure 1 – iOS 13 Light mode (left) vs dark mode (right)

In fact, dark mode is not a new concept in the digital world. In the early days of computers, nearly all monitors operated in dark mode, powered by cathode ray tubes (CRT). Nascent CRT technology was inefficient in illuminating an entire surface without burning out, resulting in the iconic display of black screens with green text. Subsequently, in the 1980s and 1990s, with the advent of graphical user interfaces (GUI) and color displays, white backgrounds with black text or other colors became the default theme ever since.

In December 2018, Samsung introduced Dark Mode on their devices as part of the Android Pie (9.0) update, followed by Apple in September 2019 with the release of iOS 13. Since then, the use of dark mode has significantly increased, as evidenced by a 47% rise in its adoption following the introduction of system-wide options in both Android and iOS. At the same time, Dark mode has become the default choice for 68% of Instagram users (Lindner, 2024). A study at Turku University also supports this, that out of 98 responses, 73,5% are active users – they try to actively seek out Dark mode toggles everywhere (Virtanen, 2023).

As the world is shifting more towards Green IT (green informational technology), a practice of creating and using environmentally sustainable computing resources and maximizing energy efficiency is one of its objectives, there is a possibility that the trend of dark mode will continue to rise. This is because dark mode extends battery life for OLED phones. This occurs because when displaying black, the OLED screen turns off the black pixels, conserving more energy. In Android Dev Summit 2018, it was reported that when displaying Google Maps in dark mode in full brightness, dark mode consumes 63% less energy than in light mode with full brightness (Android Developers, 2018). Research findings at Purdue University also support this, stating that switching to dark mode saves on average 67% of phone battery (Dash & Hu, 2021).

In conclusion, dark mode has transitioned from a technological necessity to a widely embraced feature and an energy-saving option that aligns with environmentally sustainable practices. With its increased adoption, as seen through high adoption rates and widespread preference on platforms like Instagram, the trend will likely continue. This trend highlights the importance of further research into its advantages and potential challenges, paving the way for innovations that enhance user experience.

## Research Problem

The time needed to read a word accurately was highest for the dark mode configurations under low light conditions, indicating worse performance (Dobres et al., 2017). This supports another older study, which found that visual acuity (the clarity or sharpness of vision, measured by the ability to see fine details at a specified distance) and proofreading performance (the process of reviewing the written text to identify and correct errors in grammar, spelling, punctuation, and formatting) were better in the light mode than in dark mode condition independent of participants’ age (Piepenbrock et al., 2013).

However, these studies have been conducted outside users’ natural environment in controlled laboratory settings. Moreover, their results have mainly focused on the readability aspect, which shows that dark mode results in poorer readability than light mode. However, they did not address its effect on the overall usability of the UI. Lastly, they did not explain the paradox of dark mode’s increasing adoption and popularity despite its reduced readability.

As a result, the existing research is inadequate for understanding dark mode’s popularity and its impact on usability. The existing results may also not entirely apply to typical dark mode usage contexts where different external factors, such as changing lighting conditions and varying user attention levels, play a significant role. Therefore, there is a need for a comprehensive study that addresses these gaps.

## Research Aim, Objectives, and Questions

Given the research gaps and lack of studies assessing dark mode’s impact on app usability, this study aims to identify specific usability challenges faced by dark mode users in daily usage contexts, particularly challenges that stem from its reduced readability. Additionally, it will explore the paradox of the increasing adoption of dark mode despite these challenges.

Research Objectives:

**Objective #3 – To understand the reasons behind dark mode users’ preferences and reveal the reason behind the dark mode adoption trend despite its readability challenges and some probable other challenges**

Research Questions:

**RQ #1** – Why do dark mode users activate dark mode on their devices, and what does their dark mode usage context look like? (what specific factors contribute to dark mode adoption trends and what specific usage context like time, location, situation, apps, type of work will dark mode users use dark mode more than light mode?)

RQ4: apa efek dari tidak mengimplementasi dark mode terhadap sebuah aplikasi atau produk?

**RQ #2** – How does dark mode reduced readability impact the its usability of application UIs and overall user experience? Are there any specific challenges, as well as challenges outside of readability?

**RQ #3** – Why is dark mode becoming more popular among users despite reported usability challenges? How do they weigh the pros and cons of dark mode display? What is the impact

of their usage contexts like which platform and what time, on cara mereka menimbang? Apa hanya dibeberapa tugas saja? Tugas seperti apa saja?

This study will contribute to a better understanding of dark mode’s usability and the reasons behind its increasing adoption by interviewing and observing how dark mode users interact with it in their typical environment. This will help address the current shortage of research in this area and provide valuable insights for UX/UI designers and software developers when developing dark themes for their applications.

## Scope and Limitation

(undone)

1. Highly relevant to psychology and human-computer interaction.
2. Hanya untuk hp dan smartphone context, not hmd
3. Therefore, we will solely focus on the participant’s statement without delving into the underlying reason for their behavior
4. My lack of knowledge in the medical field, thus presenting only factual information without detailed analysis.
5. Concentrates exclusively on UX/UI design topics
6. Specifically focuses on dark mode users
7. Researcher’s lack of experience in research
8. Employs qualitative and exploratory research methods susceptible to subjectivity.

## Disposition

(undone)

In chapter One, the study's context has been presented. The research objectives and questions have been outlined, along with a discussion on the significance of the research. Additionally, the study's limitations have been addressed.

In Chapter Two, the existing literature that answers the research questions will be presented thematically. The research gaps found will also be explained, and their relation to the unanswered questions will also be presented.

In Chapter Three,…

In Chapter Four,…

In Chapter Five,…

In Chapter Six,…

# Literature review

*This chapter will review and analyse the existing literature on users’ motivation for using dark mode and dark mode impact on application usability and user experience. It aims to provide a comprehensive understanding of the current knowledge and identify research gaps in this domain. (Here, I should add the scope of the literature review and what I will and will not be covering. Additionally, describe which thema answer which research questions)*

## Dark Mode and Its Adoption Trend

Dark mode is a type of display (= a way of showing text and images) on a phone, computer screen, etc., that uses a black or dark background with lighter text (Cambridge University Press & Assessment, 2024). It does not have a precisely defined color palette. Instead, it is up to the designers to decide which colors to implement to have the best possible readability and color compatibility (Eisfeld & Kristallovich, 2020). Dark mode, alongside the dark theme and night mode, is a popularized term for the light-on-dark color scheme (Eisfeld & Kristallovich, 2020). Not only that, the term negative polarity (Piepenbrock et al., 2013) is also commonly used to describe dark mode in many existing research in the field of human-computer interaction.

As for the dark mode trend, various polls and statistics (Lindner, 2024) clearly indicate a substantial number of dark mode users and a growing trend in its adoption. This increasing inclination toward dark mode is evident in a 2020 study with 2514 respondents by Android Authority (Westenberg, 2020) where 91.8% of respondents reported using some form of dark mode on their smartphones. Moreover, Eisfeld & Kristallovich (2020) conducted a qualitative literature review on this topic, analyzing publications related to Dark Mode, light-on-dark color schemes, and digital trends to understand the trend better. The study then implies that Dark Mode is here to stay, as it satisfies the preferences of many users and makes current OLED screens and future digital devices with appropriate display technology more sustainable (Eisfeld & Kristallovich, 2020).

## Reasons to Use Dark Mode and Usage Context

There could be various reasons why users activate dark mode on their devices. It may be based on informed decisions on its benefits or purely personal preference. Nevertheless, studies and surveys indicate a similar pattern in the reasons users opt for dark mode.

Reduced eye strain, battery savings, aesthetic appeal, and improved accessibility for individuals with visual impairments, such as cataracts, are often mentioned as the main drive for using dark mode (Kohler & Zhang, 2023). Additionally, a study at Turku University quantified this by revealing that 90.3% of 72 active dark mode users cited reduced eye strain or glare as their primary reason for using it, followed by aesthetic appeal (76.4%) and battery saving (26.4%). At the same time, one respondent claimed to use Dark mode for migraine and epilepsy reasons, which can be attributed to the improved accessibility aspect for individuals with visual impairments or other medical conditions (Virtanen, 2023). Moreover, another study highlighted that light mode can be too bright when used on very large monitors in control centers, making dark mode a preferred option (Eisfeld & Kristallovich, 2020).

As the study results show, the reason users use dark mode is closely related to users’ dissatisfaction with light mode. For instance, light mode screens that are too bright that put excessive strain on the eyes. Health-related reasons can also be significant motivators, suggesting that user motivation can be multifaceted and context-dependent. Also, not to mention its aesthetic and perceived battery-saving benefit. While the studies provide a comprehensive overview of the reasons users prefer dark mode, it is important to consider the context in which these preferences are expressed to be able to answer the research question of why users opt for dark mode despite its reduced readability (as described in the introduction of this bachelor thesis and to be explored in more detail later).

Firstly, it was found by Virtanen (2023) that many participants lean towards dark mode for productivity-related activities like work and study. Secondly, 69.4% of all participants decide to use dark mode completely independently of location (indoor and outdoor). It also found that 81.6% of participants do not switch between dark and light mode depending on the time of the day. Lastly, 60% of participants said they use only one mode across all applications and software. However, the remaining 40% of them were asked which applications prompted them to switch to dark mode. The results identified four types of applications where most users prefer dark mode: social media, streaming services, communication apps, and gaming (Virtanen, 2023).

The results show that a significant majority of participants associate dark mode with productivity and use it for that context. This can also be supported indirectly by the other results that the 4 types of applications where participants prefer dark mode are social media, streaming services, communication apps, and gaming, which are not really related to productivity tasks. Additionally, this suggests that specific applications can influence user preferences for toggling dark mode. Interestingly, neither time nor location significantly influences general users’ decisions to switch to dark mode, which is contrary to popular belief of the importance and increased use of dark mode during nighttime.

## Usability Issues

The usability issues of dark mode largely revolve around its readability. This can be linked to how the human eye works. The eyes’ pupils constrict (shrink) in brightness due to the abundance of light and dilate (expand) in darkness to capture more light (Mathôt & Van der Stigchel, 2015). This is referred to as the pupillary light response, which means that the smaller the pupil, the sharper the image (Campbell & Gregory, 1960). Therefore, this translates to texts appearing clearer to most users in light mode, which makes reading less strenuous. Contrarily, text tends to appear less sharp in dark mode due to the dilation of the pupil, a phenomenon that occurs in response to reduced light

### Visual Acuity and Proofreading

Piepenbrock et al. (2013) conducted a study with two adults with normal or corrected eyes. The first group was 18-33 years old, and the second group was 60-85 years old, and neither of these groups suffered from any visual disease. They were presented with two different tasks: a visual acuity task, where they were shown the letter “C” in various orientations and asked to identify where the gaps were, and a proofreading task, where they read a short passage and were told to identify various types of errors. The tasks were presented in either dark or light mode, but each participant saw only tasks in one display mode (e.g. only dark mode).

The results indicate that both participant groups exhibited better visual acuity and proofreading performance in light mode compared to dark mode. Regardless of the mode, younger participants generally outperformed their older counterparts. However, the advantage of light mode over dark mode in terms of visual acuity was less pronounced among older participants than younger ones, as depicted in Figure 2 (Piepenbrock et al., 2013).

A graph of different age groups

Description automatically generated with medium confidence

Figure 2 - Participants' visual acuity score based on age groups

The generally poorer performance of older participants compared to younger ones in both tasks, as well as the smaller advantage of light mode in visual acuity for them, is not without reason. This is due to the fact that the size of our pupils decreases, and their ability to adapt to varying light situations diminishes as we age (Lazar et al., 2024). Nevertheless, the outcomes of both tasks clearly indicate the inferiority of dark mode in the context of reading, where participants perform worse in dark mode, regardless of age. This also emphasises that age does not play a determining role when comparing user performance in light and dark modes.

### Glanceable Reading

Further research has been conducted comparing dark mode and light mode in the context of glanceable reading, and this refers to a scenario where the observer has limited time to encode the available visual and lexical information, which closely simulates the everyday situations of dark mode usage, such as when looking at a smartwatch, message notifications, or while driving. This study by Dobres et al. (2017) recruited participants aged 20-65 years with normal or corrected-to-normal vision. It measured legibility thresholds under a glance-like reading paradigm for two contrast polarities (dark mode and light mode), type sizes, and ambient lighting conditions (simulated day and nighttime). The data shows a significant effect caused by the display mode, particularly under dark ambient lighting conditions (simulated night-time). As illustrated in Figure 3, text in light mode is read faster than in dark mode, especially in dim lighting conditions (Dobres et al., 2017).

Figure 3 - The average time needed to read correctly for each condition. Adapted from (Dobres et al., 2017)

Higher judgment time at night shows that using dark mode at night is not as good as it is often claimed. This again proves the inferiority of dark mode and indirectly supports the possibility that reduced readability impacts its usability and user experience.

## Research Gap

My opinion and my view on what the gap exactly is

Lab different factors

simulated

Just text

Beberapa hasil bisa saja di influence oleh orang yang tidak terlalu menggunakan dark mode dalam sehari2 dan tentu nya berbeda oleh pengguna setia. Secara tidak langsung kita tidak bisa tau kenapa dark mode users increase dan apa memang mereka merasakan kekurangan itu atau tidak.

Mungkin tidak terbiasa membaca juga pengaruh mungkin

Efisien dan accuracy mungkin 2 hal berbeda. Aacuracy might be good tapi kalau tidak comfortable mungkin jadi tidak efisien. Jadi harus diteliti lagi bagaimana users menimbang hal ini

## Conclusion

# Research methodology

To verify all wether the same issues and motivation align kita melakukan hal yang sama, hanya dengan qualitative approach with interview to explore more stories behind each of it.

To observe the users in their natural environment 🡪 usability testing of a website with dark mode addition

Interview then asked utk tahu apa yang bisa diperbagus dan mendalami alasan dark mode userstetap pakai dark mode despite usability issues

This chapter outlines techniques applied in this study, which aim to uncover the underlying cause for the increase in dark mode adoption despite the usability challenges reported as it was stated in the literature review.

**User Interview**

Semi-structured interviews were conducted with 6 participants who are frequent dark mode users. Here, a frequent dark mode user was defined as someone who self reportedly stated to have dark mode activated on their devices the whole day, regardless day or night.

To select the participants, one question was posted on Instagram and a WhatsApp group asking people who identify as frequent dark mode users who would like to be interviewed. All participants were also asked about their dark mode usage in the interview to ensure that they are the right candidate for the research.

Interviews and usability testing were conducted remotely from May 10th – 15th, 2024 with 6 participants who were based in Germany and Netherlands. Google Meet was used for the communication. The session lasted approximately 30 to 45 minutes for each participant. All interviews were recorded with consent and transcripted with the help of an AI-powered transcription tool Riverside <https://riverside.fm/transcription> and later be refined by the researcher himself. One record of participant 5 didn’t record the participants voice and researcher must rely on his memory. While in participant 6 he didn’t have access to chrome and the researcher were showing him the website via share screen instead and ask him about his opinion on it.

# Research findings

Usability test mebuktikan kalua user aman2 saja dan tidak ada hal yang benar2 parah terjadi. Most comment also not related to readability. Ini bukti bahwa readability problem tidak terlalu signifikan bagi pengguna dark mode dalam menentukan pilihan mereka

# Discussion

1. Performance satu hal, fatigue and comfort hal lain. indicating lower visual fatigue for the dark mode compared to the light mode. Interestingly, this result is independent of the virtual lighting and applies to both bright and dim environments (Effects of Dark Mode Graphics on Visual Acuity and Fatigue with Virtual Reality Head-Mounted Displays)

Adaptation effect: dark mode users feel sensitive to light

On the otherway we get used to read long text and books in positive polarity, that’s why we hate reading long text in dark mode

A study by Pedersen et al said focus and productivitiy doesn’t have any different when compared to dark mode. So this might be more like a perception that users feels. Or maybe an indirect impact of less eyestrain that leads to the feeling they work longer and accomplish longer

The main motivator to activate dark mode, which is to reduce eyestrain, is also proven by Erickson et al., (2020) that indicates lower visual fatigue for the dark mode compared to the light mode, independent of the virtual lighting and applies to both bright and dim environments for virtual reality head-mounted display. From the user’s point of view Dark Mode increases comfort in conditions with low lighting (Eisfeld & Kristallovich, 2020).

Users also like it, to have an option and when they are in control. Yang akhir nya berkontribusi pada naik nya jumlah adopsi dark mode

The [aesthetic-usability effect](https://www.nngroup.com/articles/aesthetic-usability-effect/) predicts that, when designs are seen as attractive, people will assume that they are easier to use.

The positive polarity advantage seems to be primarily due to the typically higher overall luminance of positive polarity displays (Buchner, Mayr, and Brandt 2009).

Among many health concerns with displays, various ocular symptoms are dominant due to the direct visual stimuli on the eyes from the displays, such as eyestrain, tired eyes, and sensitivity to bright lights and eye discomfort, which are referred to as computer vision syndrome (CVS)

This suggests that factors like content type, usage context, and visual requirements of different applications play a critical role in determining whether users opt for Dark or Light mode. Especially the preference for Dark mode in social media, streaming services, and gaming suggests that users find **Dark mode more visually comfortable for engaging with media-rich content**, especially in environments with reduced lighting or during prolonged use. This might also suggest a strong preference for aesthetics especially in social media, which often revolves around picture and video content. Also, the higher preference for Light mode in productivity apps and educational platforms indicates that users might find **Light mode more practical and less distracting in work or learning contexts**. It suggests that for tasks requiring focus and detail, **such as reading text or working with data, Light mode may be perceived as clearer and better for concentration** even if previous responses in the productivity section did not reflect this.

**Focus discussion**For people who responded with ‘Yes’ or the ‘Both, depending on the task’ options additional questions were presented. These additional questions query how Dark mod 52 might affect focus or the amount of work that will be carried out. These questions are of course an individual’s own personal experience and not empirical test results, so we need to take these results with a grain of salt. Nevertheless, slight majority of the respondents expressed slight inclination towards better focus with the ‘Maybe’ answer (43,2%) and 39,8% felt like it does improve focus. 17% felt like it does not improve concentration and focus at all. The results are seen in Figure 37.

**Focus effect need to be further investigated**However, these productivity responses are quite varied and highly subjective. The fact that a significant number of respondents were unsure or did not see an increase in productivity with Dark mode suggests that its impact is not universally recognized or felt. It seems that productivity is a good motivator for Dark mode usage, but its perceived usefulness requires more in-depth analysis.

**Ternyata battery life consumption engga terlalu disebut**Contrary to the hypothesis, a significant majority of respondents, 59.2%, indicated that they do not switch to Dark mode on their mobile devices for the purpose of conserving battery life. This finding is particularly interesting as we assumed that battery savings are a large motivator for opting for Dark mode, at least among the users who participated in our survey.

**Unaware of OLED battery saving benefits** This awareness aspect is also evident in the subsequent question 15. where we asked, ‘Were you aware before this survey that using Dark mode could potentially save battery life on your mobile device?’. In this question majority responded with ‘Yes’ (61,2%), however a large portion was unaware of the battery conservation implications (38,8%). Results are presented in Figure 42.

This additional question asked whether respondents would now switch to Dark mode as it could be more sustainable and energy efficient. Majority opted for ‘Yes’ (84,2%) and small minority replied with a ‘No’ (15,8%). This implies that **users value practical benefits and are willing to modify their preferences accordingly**.

**Aesthetic over practical benefits** Majority of 61.2% of respondents answered ‘Yes’, indicating their willingness to switch back to Light mode despite its higher battery consumption if they found Dark mode aesthetically unappealing. This response ties back to the of visual appeal and aesthetics in influencing user choices.

**Equal Importance of functional benefits and aesthetic appeal** ‘If you use Dark Mode, is your choice to use Dark Mode mainly influenced by its aesthetic appeal rather than any functional benefits?’ The response 48 revealed a significant inclination towards a balanced view, with 61.2% of participants selecting ‘Both equally’, indicating that aesthetic appeal and functional benefits are of equal importance

**Dark mode users think, benefits Apply to all type of content** Next, we asked does the dark theme preference apply to all types of content or only some specific types of content. This also ties with the application specific question later in this thesis. Majority think that is preference is universal (81.6%). However, there was quite a lot of variances with ‘Other’ responses, as respondents wanted to specify their preference. Many of these answers were related to coding and syntax highlighting – a common use case for dark theme. Some also prefer to use it in books, articles and blogs, platforms where text is the primary medium. Some also pointed out that if the overall design of a site uses a particular theme, it might affect their choice.

**Different theming based on apps** Most users were within this group (59,2%), however 40,8% of respondents did tend to use different theming depending on the specific application.

**Easier to read** Di Virtanen ada 50% persen netral dan 38% ya easier to read. Results show that there is a small incline that readability might motivate to people use dark mode, but majority are neural regarding it.

**Pop up more** In addition, respondents who answered ‘Yes’ were presented with additional two questions regarding readability…. We first asked if dark mode improves colour and text highlighting as this often referred in official documentation of Dark themes, such as Apple’s developer documentation [48]. Majority of respondents reaffirm this claim with 65,8% responding with a ‘Yes’.

A screenshot of a graph

Description automatically generated

One major theme amongst these was poor implementation and effect on general readability. This includes issues like poor contrast, visibility of UI elements, and overall design. Some also pointed out that **Dark mode is often preferred in applications where the media** content is the main focal point like Netflix or editing content like in Photoshop.

Many respondents mentioned using Light mode for tasks **requiring concentration on text**, like reading or typing, due to better readability. Dark mode is favoured **for coding or system use, where it is seen as less straining especially in low-light environments**. We are seeing a theme of productivity vs. entertainment in the responses.

A pie chart with a number of different colored circles

Description automatically generated

A pie chart with a number of different colored circles

Description automatically generated with medium confidence

A screenshot of a computer

Description automatically generated

**So, Should We Support Dark Mode?**

It’s debatable how much a design team who is trying to prioritize time and stretch a budget should worry about arguably reduced eye strain or minimal battery savings for users.

However, it is *not* debatable that many users like the dark mode aesthetic, which might be reason enough to support it. (Just not at the expense of fixing real usability issues!) Additionally, the benefits for those with visual impairments are also important and should be discussed as part of larger [accessibility considerations](https://www.nngroup.com/articles/visual-treatments-accessibility/) within the organization. **Aesthetic appeal and improved accessibility are the strongest arguments for supporting dark mode.**

Not applying dark mode effect

The final section of the questionnaire asked the respondents themselves if they would recommend an incorporation of Dark mode for different platforms and applications where it is not found yet. Majority were in favour of a recommendation (85,7%) while a small subset was neutral (14,3%). Nobody opted for ‘No’, which is telling sign that users want to add more interface theming options and increase their availability. The results are seen in Figure 49.

A pie chart with a number of different colored circles

Description automatically generated with medium confidence

A graph with numbers and lines

Description automatically generated

# Conclusion

# 

Bahkan bagi dark mode user ada beberpa konteks mereka mengganti. Meskipun begitu sensitifitas terhadap Cahaya dan aesthetical reason dapat dijadikan sebagai alas an utama yang berkontribusi terhadap trend.

Sementara issue dari readability dark mode memang benar adanya dan bahkan di perceive oleh dark mode users. Riset lebih lanjut untuk membuat guideline seperti apa yang bisa di mitigate (krn terbatas nya waktu jadi ga bisa)

Meskipun demikian issue readabilitas ini tidak terlalu berdampak pada dark mode users, dikarenakan….; instead switch ke light mode completely to not have this, dark mode users only opt for light mode in some cases

Ditambah lagi , penggunaan dark mode yang pada dasarnya tergantung dari tipe tugas, jumlah bacaan membuat orang tetap stay, Dimana meraka tidak terlalu perlu membaca

Ask prof how should our approach be when finding a study that is almost similar.

However udah dibilang sama si author nya sih kalau:

Also, a **more qualitative approach could prove useful**. Understanding the reasons behind each user’s preference can provide context that pure quantitative data may not reveal. The open-ended responses found in this study gave interesting insights to how some users opt for Dark mode and what they would like to see improved in modern user interfaces. Even specific further interviews with these users could give more details about Dark mode motivators

# Further study

Participant emg bilang beberapa hal yang menurut mereka dapat dilakukan utk bisa buat dark mode lebih readable. Namun studi yang mungkin bisa menyatukan apa saja cara mitigate berdasarkan riset2 yang ada, mungkin akan lebih bagus lagi

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# Appendices