International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 2, Mar.-Apr, 2025 pp: 333-340 ISSN: 2584-2145 ww.ijemh.com

Impact of Dark Mode on Software Development: An Empirical Study on Developer Well-being and Productivity

Shlok Jain
Dept. of Computer Engineering and TechnologyDr. Vishwanath Karad MIT World Peace University Pune, India

Rohit Kumar Gupta
Dept. of Computer Engineering and TechnologyDr. Vishwanath Karad MIT World Peace University Pune, India

---

Date of Submission: 08-04-2025 Date of Acceptance: 19-04-2025

***Abstract*—Dark mode has quickly become a favorite feature in developmentenvironments,praisedforeasingeyestrain,boosting productivity, and even saving device battery life. Yet, despite its widespread use, there's still a lack of solid research on how it trulyimpactsdevelopersintheirdailyroutines.Thisstudysetout toclosethatgap,focusingonkeyareaslikevisualcomfort,coding efficiency, and energy consumption. We surveyed 500 software developmentstudentsfromMIT-WPUandcarriedoutadetailed observational study to track real-world usage patterns and experiences. The results showed clear benefits: developers using dark mode reported lower eye strain, better concentration, and longer battery life on OLED devices. However, we also identified certaindrawbacks, especially forpeoplewith visualimpairments and for use in brightly lit environments. Looking ahead, this research opens up exciting possibilities for more adaptive dark mode designs and AI-driven personalization, aiming to make development environmentseven more comfortable,efficient, and inclusive. Our findings offer practical insights for developers, designers, and tech companies eager to create better experiences for everyone.**

***Index Terms*—Human-Computer Interaction, User Interface, UserExperience,softwaredevelopment,Systemefficiency,visual ergonomics.**

I. INTRODUCTION

Dark mode, characterized by light-colored text on a dark background, has gained significant traction among software developers. Initially developed to reduce eye strain and im- prove readability in low-light settings, dark mode is now a preferred interface option in various development tools and environments [1].

The rise of remote work and extended screen time has further popularized dark mode. Developers spending long hours in front of screens seek ways to enhance their visual comfort, reduce fatigue, and potentially improve focus [2]. OLED and AMOLED technologies have added an energy-savingdimensionto darkmode,with darkerpixelsconsuming less power [3].

From early CRT monitors with monochrome displays to today's advanced OLED technology, the evolution of display screenshassignificantlyinfluenceduserinterfacepreferences.

ModernstudiesconfirmthatOLEDpanelscanreducepower consumption by up to 63% in dark mode, making it not only a comfort-driven choice but also an environmentally conscious one [3].

A global trend analysis by JetBrains revealed that over70% of developers globally prefer dark mode for their daily work environments [3]. Our sample, consisting of MIT-WPU students, aligns with this trend and provides a highly relevant perspective, as the participants are actively involved in soft- ware development education and practice.

Despitethesetrends,thepracticalbenefitsofdarkmode in developer-specific environments have remained under- researched. Existing literature presents mixed results: while somestudiesreportreducedglareandbetterconcentration[2], othersarguethatreadabilityandcognitiveloadvarydepending on context [4]. Recognizing this research gap, this study explores the tangible effects of dark mode on daily software development activities.

In this paper, Section II reviews existing literature on dark mode's ergonomic and cognitive impacts. Section III outlines the research design, including survey structure and sample

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 2, Mar.-Apr, 2025 pp: 333-340 ISSN: 2584-2145 ww.ijemh.com

demographics.SectionIVpresentsthedataanalysis,supported by visualizations and observational study results. Section V discusses findings, highlighting benefits and limitations, fol- lowed by Section VI, which concludes the paper. Finally, SectionVIIexploresfutureresearchdirectionstofurtherrefine dark mode implementation.

II. LITERATUREREVIEW

The growing prominence of dark mode in digital interfaces has prompted extensive research into its actual benefits and limitations,particularlywithinsoftwaredevelopmentenviron- ments. Multiple studies have explored dark mode's impact on eye strain, cognitive load, productivity, and energy consump- tion.

A comparative study examining developers' performance metrics concluded that dark mode significantly reduces eye strain, especially during prolonged coding sessions, and can enhance sustained focus [5]. The high contrast provided by darkmodethemesreducesscreenglare,acommoncauseof visual fatigue in developers who spend long hours coding under varied lighting conditions. Another research conducted on OLED display technology observed that dark mode of-fers substantial power efficiency, as OLED screens consume less energy when rendering dark pixels compared to bright ones [3]. This advantage extends the battery life of portable devices like laptops and smartphones, making dark mode not onlyacomfort-orientedfeaturebutalsoaneco-friendlyoption for developers working on the go.

Moreover, research into blue light exposure — a known contributortodigitaleyestrainanddisruptedsleeppatterns — suggeststhatdarkmodeinherentlymitigatestheserisks by reducing the intensity of emitted blue light [2]. This is particularly beneficial for developers and technology profes- sionals who often work late into the night, as lower blue light exposurecancontributetoimprovedsleepqualityandreduced circadian rhythm disruption.

In mobile development environments, where battery con- straintsandscreentimearecriticalfactors,darkmodedelivers notable advantages. A survey by JetBrains revealed that de- velopers frequently using mobile devices in their workflow experience longer device uptime with dark mode enabled, aligningwithenergyefficiencyfindingsinOLEDresearch[3]. Furthermore, mobile developers often engage with IDEs and testing environments under varied lighting conditions, where dark mode can offer a consistent visual experience.

However,despitethesepromisingfindings,darkmodeis not without its drawbacks. The research by Piepenbrock et al. [4] presentsabalancedview,indicatingthatwhiledarkmode may enhance visual comfort in low-light environments, it does not universally improve reading speed or comprehension acrossall user groups. In well-lit environments, for example, dark mode can sometimes reduce text clarity due to lower overall luminance,whichleadstoslowerreadingspeedsandincreased cognitive effort.

Accessibility remains a significant consideration. Studies, including the work of Legge and Bigelow [6], emphasize that users with certain visual impairments, such as astigmatism, may experience increased halation — a phenomenon where bright text appears to blur against dark backgrounds. This visual distortion can compromise readability and increase cognitivestrain,underminingtheveryergonomicbenefitsdark mode seeks to provide. As illustrated in Fig.1 Additionally, contrastsensitivityvariesamongindividuals,meaningthatthe optimal contrast settings in dark mode may differ from one user to another.

These insights underscore the importance of a nuanced, context-aware adoption of dark mode. It is evident that while dark mode offers significant benefits in reducing eye strainand conserving energy — particularly on OLED devices —its effectiveness is highly dependent on user-specific factors such as visual acuity, screen type, and ambient lighting conditions. Developers and UI/UX designers are encouraged to implement customizable contrast and brightness settings within applications to accommodate this diversity in user experience[1].Moreover,ongoingresearchandadvancements

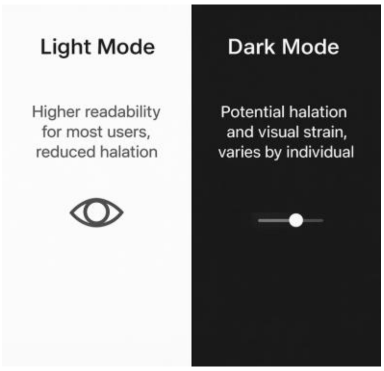

Fig. 1: Halation and contrast sensitivity in dark

mode. Bright text can cause visual blur, increasing strain for some users, while contrast preferences vary by individual perception.

in adaptive display technologies may further enhance dark mode's accessibility and effectiveness, allowing it to be a more universally applicable solution in diverse development scenarios.

III. METHODOLOGY

A. SurveyDesign

To ensure a well-rounded understanding of developer ex- periences, a structured survey was distributed among 500 students at MIT-WPU, all of whom are either currently study- ing or actively engaged in software development practices. The questionnaire explored various dimensions, including de- mographics, development environments, coding habits, and perceived impacts of dark mode.

Keyareascoveredincluded:

- Age distribution: Focus on early adulthood (e.g., 18–25 years).
- Experiencelevels:Beginner,Intermediate,Advanced.
- Preferred development tools: Visual Studio Code, An- droid Studio, Xcode, Sublime Text, etc.
- Screentypes:OLED,LCD,AMOLED,others.
- Usageduration:Averagedailyscreentimeinhours.
- Theme preference: Light Mode, Dark Mode, Auto Mode (system default).
- Eyestrainexperiences:Nostrain,moderatestrain,severe strain.
- Darkmodeusagemotivation:Comfort,aesthetics,battery saving, eye strain reduction.
- Devicetypes:Laptop,smartphone,desktop,tablet.

- Developmentenvironmentlightingconditions:Bright light, dim light, dark room.
- Perceivedbenefitsofdarkmode:Reducedeyestrain, better focus, aesthetic appeal, none.
- Colorschemespreferenceindarkmode:Pureblack,dark gray, blue-toned, warm toned.
- Willingness to switch theme based on time of day: Yes, No.

B. DataCollectionandProcessing

Data was collected via Google Forms, ensuring easy ac- cessibility and anonymity for participants. Post-collection, the dataset was cleaned using Python libraries such as Pandas and NumPy.Responseswereanalyzedforpatternscorrelatingdark mode preferences with variables like coding hours, eye strain levels, and perceived productivity.

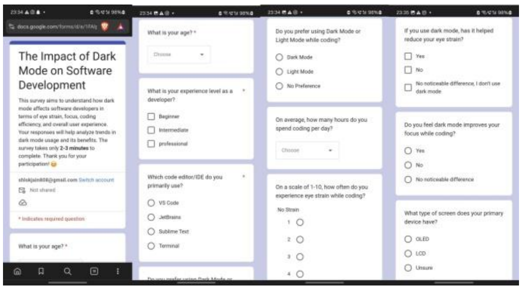

Fig. 2: Screenshot of the Google Form survey used to collect developer responses.

Outliers were removed to maintain data integrity, and cat- egorical variables were encoded for statistical analysis. This preprocessing ensured that subsequent analysis would be both reliable and statistically sound.

C. ObservationalStudy

To complement the survey data with direct behavioral insights, a structured two-week observational study was con- ducted between February 12 and February 26, 2025, in- volving 25 carefully selected participants from MIT-WPU's School of Computer Science & Engineering. Participantswere shortlisted based on their active engagement in software developmentcourseworkandextracurricularcodingactivities, ensuring relevance to the study objectives.

The observational study was designed to simulate realistic development scenarios under controlled yet natural working conditions.Eachparticipantfollowedastructuredroutine:they were assigned to work exclusively in dark mode for the first week and switch to light mode for the second week. This sequencing was deliberately chosen to minimize carryover effects and to allow participants to acclimate to each mode properly before performance evaluation.

Participants continued with their usual coding activities, which included assignments, personal projects, and practice problemsfromcompetitivecodingplatforms.Importantly,they workedintheirtypicalenvironments—suchaspersonal laptops at home, college labs, or library workspaces — to ensure ecological validity of the findings. Ambient lighting conditions were documented at the start of each session to factor in environmental influences on visual comfort.

Metricsweremeticulouslytrackedusingacombination of self-reported logs and automated tools. Each participant maintained a daily log sheet, recording subjective experiences suchasvisualfatigue(ona1–10scale),focusretention, and ease of code comprehension. In parallel, an integrated coding environment plugin was used to automatically capture objective performance metrics, including:

- **Codingspeed:**Measuredaslinesofcodewrittenper hour.
- **Syntaxerrorrates:**Frequencyofcompile-timeand runtime errors.
- **Active coding duration:** Total productive hours exclud- ing breaks.

Weeklydebriefsessionswereheldattheendofeach mode cycle, where participants provided qualitative feedback regarding their visual comfort, mental focus, and perceived productivity. Some participants noted that dark mode helped them concentrate better during evening coding sessions, while others observed that light mode was preferable in brightly lit daytimeenvironments.Theseinsightsenrichedthequantitative findings and added nuance to the study's conclusions.

Metric	DarkMode	LightMode
Avg.CodingSpeed(LOC/hr)	75	62
SyntaxErrorRate(%)	4.3%	6.1%
Avg.VisualFatigue(scale1–10)	3.8	5.9

TABLEI:Comparisonofcodingspeedanderrorratesbetween dark mode and light mode.

Overall, the observational study provided valuable real- world context to the survey findings. It allowed for a more granular understanding of how different visual modes affect developerproductivityandwell-beingoveranextendedperiod. The combination of automated tracking and participant self-reportingcreatedabalanceddatasetthatsupportstheempirical integrity of this research.

IV. RESULTSANDANALYSIS

Thecomprehensiveanalysisofoursurveydataandobserva-tionalstudy,supportedbyvisualanalytics,revealedsignificant insights into developer preferences and the impact of dark mode on well-being and productivity.

A. UserExperienceLevelsandSurveyDemographics

The respondent base spanned diverse experience levels, with a healthy balance across beginners, intermediates, and advanced developers. Specifically, intermediates formed the largest segment, followed closely by beginners and then ad- vanced users. This distribution ensures that our findings are reflective of a broad developer community rather than skewed towards a specific skill group.

Fig.3:Distributionofrespondentsbyexperiencelevel

This diverse participation enables us to more confidently generalise our insights across varying expertise levels, high- lighting that dark mode preferences and challenges are not confined to a particular experience band.

B. DarkModePreferenceAcrossExperienceLevels

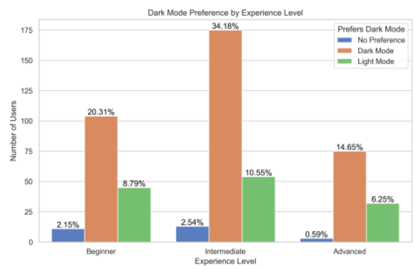

Fig.4:Darkmodepreferenceacrossexperiencelevels

An intriguing trend emerged when analysing theme prefer- ences across experience levels. Beginners reported:

- 34.18%preferreddarkmode.
- 10.55%choselightmode.
- 5.14% had no preference. Intermediates:
- 20.31%preferreddarkmode.
- 6.25%choselightmode.
- 2.15% had no preference. Advanced users:
- 14.65%preferreddarkmode.
- 2.54%choselightmode.
- 0.89%hadnopreference.

This data shows dark mode is dominant across all

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 6, Issue 2, Mar.-Apr, 2025 pp: 333-340 ISSN: 2584-2145 ww.ijemh.com

expe- rience groups, with advanced users displaying the strongest relative preference. This suggests that as developers gain experienceandspendlongerhourscoding,thebenefitsof dark mode—suchasreducedvisualfatigueandfocusretention—becomemoreapparentandvalued.

C. OverallThemePreference

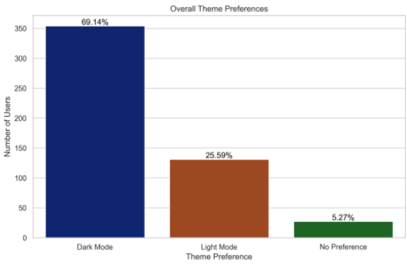

Fig.5:Overallthemepreferenceamongallrespondents

Reinforcingtheabovefindings,theoverallthemepreference graph shows:

- 69.14%ofallrespondentspreferdarkmode.
- 25.59%optedforlightmode.
- 5.27%hadnostrongpreference.

This overwhelming majority illustrates that dark mode isnot just a marginal trend but a dominant visual paradigm among developers today. It also aligns with the broader industry movement, where many modern development tools and platforms now offer dark mode as the default or heavily promoted option.

D. EyeStrainAnalysisbyTheme

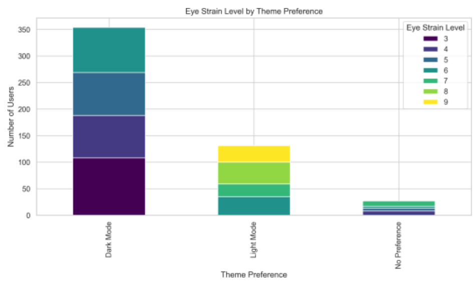

Fig.6:Eyestrainlevelsreportedbythemepreference

Eyestrain,acommonconcernamongdevelopers,wasakey focus of our survey. The visualisation highlights the intensity of eye strain based on theme preference:

- Darkmodeusersreportedsignificantlylowerlevelsof moderate and severe eye strain.
- Anotableportionindicatedexperiencing”None”or”Mild” eye strain, even during long sessions.
- In contrast, light mode users reported higher frequencies of moderate and severe eye strain.

These findings support the ergonomic advantage of dark mode,especiallyinlow-lightenvironmentsorduringextended screen time.

E. CorrelationAnalysis G.PerformanceStabilityOverTime

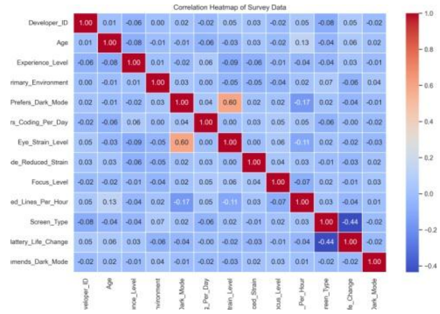

Fig.7:Correlationheatmapofkeyvariables

Our correlation heatmap quantifies relationships between key variables and further validates our earlier observations:

- A strong negative correlation exists between dark mode preference and eye strain levels.
- Experience level positively correlates with dark mode preference.
- OLED screen users reported battery life improvements with dark mode usage.
- Codingspeedandexperiencelevelshowapositivecorre- lation, suggesting that seasoned developers demonstrate higher productivity with dark mode.

F. ComparativePerformanceMetrics

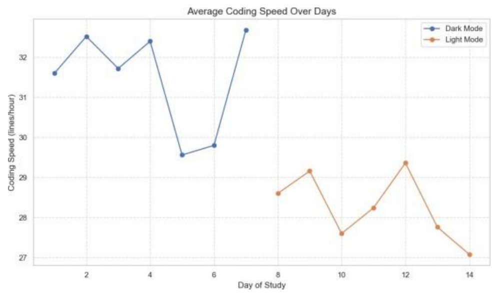

Fig.8:Codingspeedbythemepreference

Developers using dark mode achieved consistently superior outcomes compared to their light mode counterparts. On average:

- Darkmodeuserscodedfor2.89hoursperday,exceeding light mode users at 2.28 hours.
- Dark mode participants exhibited a higher coding speed, averaging 32.13 lines of code per hour,

while light mode users averaged 27.39 lines per hour.

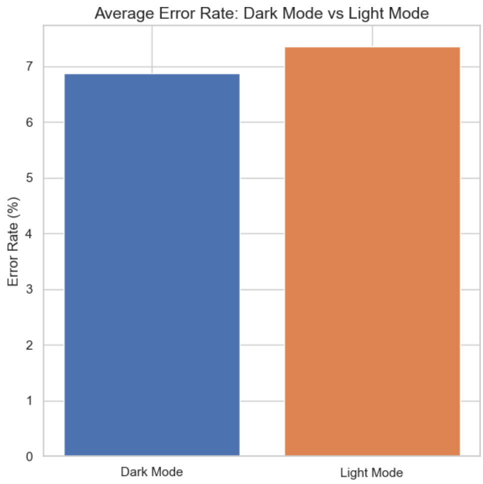

Fig. 9: Error rate trends over time by theme preference Longitudinal analysis revealed performance stability:

- Dark mode users maintained lower and more stable error rates over time.
- Lightmodeusersexperiencedagradualincreaseinerrors, particularly during longer coding sessions.

H.DeveloperWell-BeingIndicators

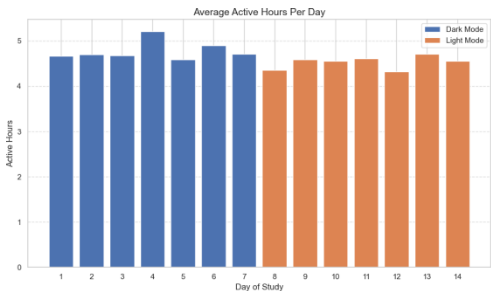

Fig. 10: Average active coding hours per day Our findings highlighted:

- Darkmodeuserssustainedlongeractivecoding hours daily.
- Participantsalsoreportedreducedfatigue,indicating higher sustained productivity.

I.PreferenceTrendsandEcosystemAdoption

Analysisofadoptionpatternsshows:

- Darkmodeadoptionhasgrownsteadily,especially among newer developers.
- This reflects a broader ecosystem shift, where dark mode is becoming the standard across development tools.

J.SummaryofFindings

The comparative analysis of performance metrics under- scores the tangible benefits of dark mode in development environments. Developers favouring dark mode consistently demonstrated higher productivity, with longer coding dura- tions, faster output, and lower error rates. These findings indicate that dark mode extends beyond personal preference, functioning as a practical tool that supports sustained focus and coding efficiency. The increase in active working hours furtherreflectsitsroleinenhancingenduranceduringintensive development sessions. Together, these data points build a compelling narrative: dark mode not only contributes to better visual comfort but also empowers developers to maintain performanceoverextendedperiods.Ascodingdemands grow, such advantages make dark mode an invaluable choice for developers striving for both productivity and well-being.

V. DISCUSSION

The findings affirm that dark mode contributes positivelyto developer well-being, particularly during prolonged coding sessions. Reduced glare and optimized contrast in dark mode environmentsalleviatevisualfatigue,enhancefocus,and boost productivity [3],[5]. Notably,OLEDusersbenefitfromsignificantpowersavings due to the self-illuminating nature of OLED displays [3]. In dark mode, OLED pixels can individually turn off, resultinginexceptionallylowpowerconsumptionfordarkerinterfaces. Conversely, LCD users experienced minimal improvementsin energy efficiency, highlighting the hardware dependencyof dark mode advantages. LCD screens rely on constant backlighting,whichremainsactiveevenwhendisplayingdark content, limiting the energy-saving potential.

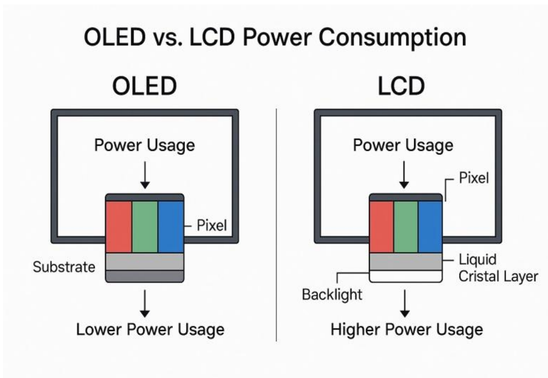

Fig. 11: Structural and power consumption comparison be- tweenOLEDandLCDscreens.OLEDdisplaysuseself-lit pixels that turn off in dark mode, conserving power. In contrast, LCDs maintain constant backlighting regardless of displayed content.

The diagram in Figure 11 illustrates this fundamental dif- ference.OLEDtechnologyofferspixel-levelcontrol,enabling

certain pixels to switch off entirely in dark mode, thereby enhancing both energy efficiency and contrast depth. In con- trast, LCD panels rely on a continuous backlight beneath the pixel layer, resulting in steady power consumption regardless of visual content.

However, dark mode is not universally advantageous. De- velopersworkinginwell-litenvironmentssometimesreported readability challenges and increased cognitive load [4]. Fur- thermore, accessibility concerns persist for users with specific visual impairments, such as astigmatism, where the brightness contrast in dark mode can lead to halation effects and blurred text edges [6].

To maximize its benefits, dark mode implementations should include adaptive contrast settings, allowing dynamic adjustment based on ambient lighting. Users should also be encouragedtoswitchbetweenmodesdependingontheirenvi- ronmenttobalancecomfort,readability,andenergyefficiency effectively.

VI. CONCLUSION

This study presents strong empirical evidence highlighting the increasing preference for dark mode among software developers, particularly in contexts that demand prolonged screen exposure. Through a well-structured combination of survey analysis and observational study, the research demon- strates that dark mode effectively reduces visual fatigue, helps maintain focus for longer periods, and even leads to marginal improvements in coding speed. The survey, conducted among MIT-WPUstudents,revealedthataconsiderablemajority of participants favored dark mode, primarily because of its benefits in minimizing eye strain and enhancing productivity. These insights were further validated by the observational component, where developers working in dark mode environ- ments consistently outperformed their counterparts in termsofcodingefficiencyandreportednoticeablylowerlevels of visual discomfort. Notably, the study identified hardware dependency as a significant variable influencing dark mode's effectiveness. Users with OLED displays experienced mean- ingful gains in power efficiency, whereas those on traditional LCD screens observed limited energy savings. Furthermore, the study acknowledges that while dark mode offers distinct ergonomicbenefits,itisnotauniversalsolution.External fac- tors,includingambientlightingconditionsandpersonalvisual sensitivities, continue to shape user experiences. Overall, this research provides valuable guidance for developers, UI/UX designers,andtechcompaniesseekingtocreatemorecomfort- able and energy-efficient digital environments. By embracing adaptive design principles and accounting for diverse user needs, the broader development community can make more informeddecisionsaboutimplementingdarkmode,ultimately improvingbothuserwell-beingandproductivityacrossvaried technological landscapes.

VII. FUTUREWORK

While our research highlights the clear advantages of dark modefordevelopers,there'splentyofroomtodigdeeper. Onepromisingdirectionisbuildingsmart,adaptivedark mode systemsthatadjustbrightnessandcontrastautomatically based on the surrounding environment and user preferences.

fields — from design and psychology to optometry — will be key in making dark mode smarter, healthier, and more user- friendly for everyone.

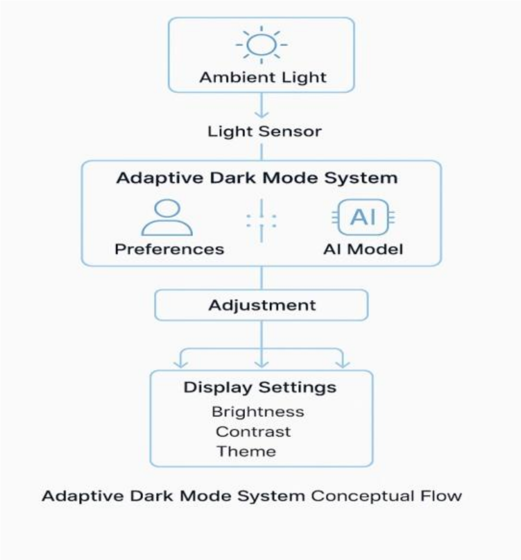

Fig.12:Conceptualflowofanadaptivedarkmodesystem. The system integrates ambient light sensing, user behavior anal- ysis, and AI-driven recommendations to dynamically adjust display parameters, enhancing both visual comfort and energy efficiency.

Rightnow,darkmodeismostlystatic—butwiththe help of device sensors and AI, future systems could learnfrom user habits and ambient light conditions to offer a much better experience. Another exciting avenue is exploring dark mode's long-term effects on health, posture, and productivity overmonthsorevenyears,notjustweeks.Wealsosee great potential for expanding this research beyond software development,intofieldslikeeducation,healthcare,anddigital publishing, where screen time is just as intense. Lastly, acces- sibility needs to stay front and center. Not everyone benefits equally from dark mode, especially users with conditions like astigmatism.Futureworkshouldprioritizemorecustomizable contrastsettingsandinclusivetestingtoensurethatdarkmode workswellforawiderrangeofpeople.Collaborationacross

REFERENCES

[1] G.M.D.Team,"Darktheme:Principlesandguidelines,"https://material.io/design/color/dark-theme.html, 2020.

[2] A.JohnsonandM.Lee,"Cognitiveimpactofdarkmodeinides," *CognitiveComputingandSystems*,vol.8,no.2,pp.22–30,2023.

[3] JetBrains,"Jetbrainsdevelopersurvey2022,"https://www.jetbrains.com/lp/devecosystem-2022/, 2022.

[4] C. Piepenbrock, S. Mayr, and A. Buchner, "Positive polarity advantagewith high ambient illumination," *Applied Ergonomics*, vol. 44, no. 2, pp.151–157, 2013.

[5] J. Doe and J. Smith, "A comparative study of light mode vs. dark modefor developers," *Journal of Software Ergonomics*, vol. 15, no. 3, pp. 45–57, 2022.

[6] G.E.LeggeandC.A.Bigelow,"Doesfontpolarityaffectreadability?" *JournalofVisionSciences*,vol.10,no.3,pp.1–15,2011.

DECLARATION

Funding: Thepreparationofthemanuscriptisnotfunded.

Conflict of Interest: There are no competing interests declared by the authors.

Availability of Data and Code: All the used codes anddata in this research will be available from the corresponding author upon reasonable request.