Mathematical Modeling of Computer Visual Syndrome Risk from Learning Application Design by UI/UX Approach and Runge-Kutta Differentiation

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Abstract. Computer Vision Syndrome (CVS) due to long-term computer use is the number one occupational hazard of the 21st century with internal, external, and visual symptoms. This research aims to evaluate the UI/UX of the Balinese writing learning application based on user experience. The evaluation uses the heuristic method proposed by Nielsen and Molich to determine the level of CVS experienced by users. From the research data, it is known that duration has a significant effect ($p<0.05$) on the level of CVS symptoms after using the application for 3-4 hours, 4-5 hours, and more than 5 hours respectively at 29.46%, 34, 26%, and 36.28% previous implementation. From mathematical modeling using the Runge-Kutta differentiation method to model each parameter of CVS symptoms towards increasing CVS symptoms using a learning application, it shows that the use of an ergonomic drawing tablet learning application with a UI/UX approach provides a lower CVS prevalence of 38.2% so that the user's eye health level in learning to write Modre Bali increases. Apart from the ergonomic drawing UI/UX design, the tablet can reduce the risk of internal ocular symptoms when using the application for a long time and tends to be stable

Keywords: Computer Vision Syndrome, user interface, user experience, heuristic method, Runge-Kutta differentiation Introduction

Computer Vision Syndrome (CVS) is a prevalent occupational health problem affecting people who use computers for extended periods, and it is considered the primary employment danger in the 21st century [1]. In the digital era, workers are required to use computer software to fulfill documentation tasks. In addition to the professional realm, the educational sphere has also transitioned to a learning approach centered around computer applications in this digital age. Various apps are utilized in the process of digitizing current characters to aid in the learning process. Due to the intricate format of modre characters, pupils are often compelled to utilize computer software to produce them, which can result in more than 2 hours of effort. Individuals who use computers for over 2-3 hours daily are susceptible to getting Computer Vision Syndrome (CVS) [2]. To write modre characters accurately, one must pay close attention to visual details to prevent mistakes. Overemphasis on visual aspects when learning to write current

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characters might impact the user's visual capabilities, including uncorrected refractive problems, accumulator disorders, and eye anomalies [3]. Prolonged use may lead to Computer Vision Syndrome (CVS) in users, resulting in symptoms like headaches, dry and painful eyes, and eye pain [4].

To minimize the risk of Computer Vision Syndrome (CVS) when typing extensively on a computer, the application is equipped with an ergonomic interface to enhance user comfort when typing. The application interface is built with a design thinking approach to ensure user-friendliness, comfort, and risk reduction related to CVS. To assess the risk level of CVS associated with using the application for writing more characters, a heuristic evaluation of the application interface is conducted. This evaluation involves mathematical modeling based on the classification of CVS symptoms, including internal ocular symptoms (eye strain and pain), external ocular symptoms (dry and irritated eyes), and visual symptoms (blurred vision and double vision). The application is built with an ergonomic interface to lessen the danger of Computer Vision Syndrome (CVS) when typing a large number of characters on a computer. The application interface is created with a design thinking approach [9] to provide user-friendliness, and comfort, and minimize the risk of Computer Vision Syndrome (CVS) [10]. To assess the risk level of CVS associated with using the application for writing more characters, the application interface is heuristically evaluated through mathematical modeling based on the classification of CVS symptoms [4], including internal ocular symptoms (eye strain and pain), external ocular symptoms (dry and irritated eyes), and visual symptoms (blurred vision and double vision).

A CVS risk model can be constructed numerically using the three natural symptoms of CVS by utilizing computers to learn how to write current characters through a differential equation model employing the Runge-Kutta method. The Runge-Kutta method is a numerical technique utilized for solving ordinary differential equations with relatively high precision [5]. This method is frequently employed to solve non-linear differential equations by using initial conditions as parameters to create differentiation models. In this instance, the mathematical model for CVS risk is completed by formulating a non-linear differential equation using variables that represent CVS risk.

1 Materials

This research aims to assess the comfort and danger associated with utilizing CVS applications when writing more characters. Usability testing is conducted to assess how readily an application can give convenience to users and mitigate the risk of CVS [2]. To assess the risk level of CVS associated with using the application for writing more characters, a heuristic is applied to evaluate the application interface [6], [7]. This heuristic is developed through mathematical modeling based on the classification of CVS symptoms into three classes, including ocular symptoms. Internal symptoms include eye strain and pain, while external ocular symptoms consist of dry, itchy, and burning eyes [4], [8]. Visual symptoms may manifest as blurred vision or double vision. A mathematical model was used to assess the overall risk level of Computer Vision

Syndrome (CVS) when utilizing apps to write characters using non-linear approaches with Runge-Kutta differentiation [8].

2 Research Method

The CVS risk model was developed using a Runge Kutta non-linear differential equation system that incorporates variables representing internal ocular symptoms (I), external ocular symptoms (E), and visual symptoms (V). The model was calibrated using data on ocular and visual.

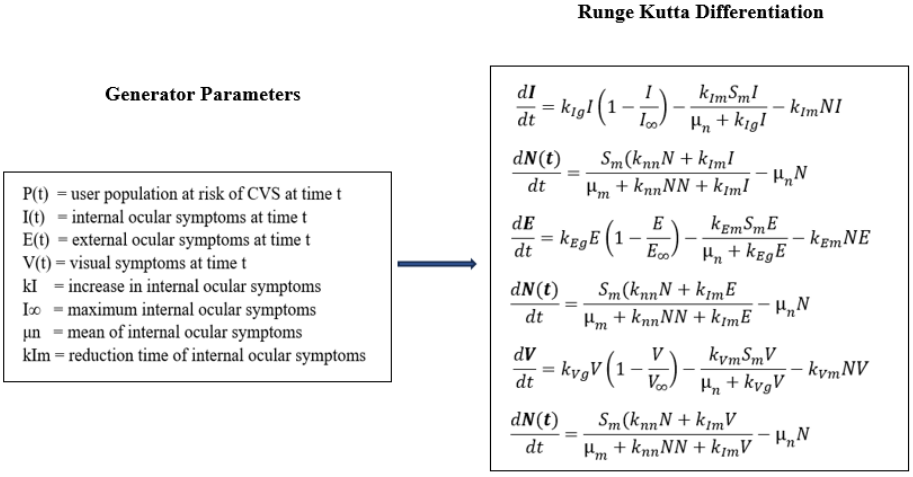


Figure 1. Runge-Kutta Differentiation Modeling

Each parameter affecting CVS risk is calculated using the Runge-Kutta differentiation method to determine the specific impact of each parameter on CVS risk. The following step is a process of generalization for each parameter to determine the impact weight of each parameter on CVS risk [8] by performing differential calculations using Equation 1.

$$\frac{dX_i(t)}{dt} = \frac{S_n(k_nN+k_{in}X_i}{\mu_n+k_nN+k_tV}-\mu_nV \quad (1)$$

The symbol μ represents the average of internal ocular symptoms, while k represents the increase in internal ocular symptoms for population i. Stage three involves determining CVS risk using the Runge-Kutta algorithm based on weight values obtained from differentiating each parameter partially with methods outlined in Figure 2.

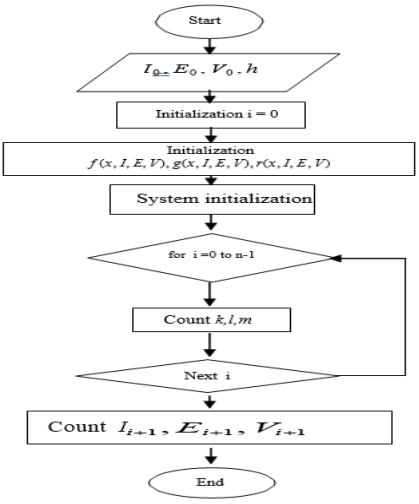


Figure 2. Runge Kutta Algorithm Flowchart

3 Result and Discussion

This study included 50 modern character authors who utilized ergonomic drawing tablet programs, comprising 20 women and 30 males. Out of the 50 individuals, 14 wore glasses whereas 36 did not. A chi-square test was conducted at a significance level of $\alpha = 0.05$ to determine if there were significant differences in the risk of computer vision syndrome (CVS) between men and women, based on whether they wore glasses or not. The results are presented in Table 1.

Table 1. CVS Risks of Ergonomic Drawing Tablet User Data Based on Gender and Use of Glasses

Demographic Characteristics	Duration of Tablet Use (Hours)			p
	3-4	4-5	Less than 5	
Gender, n (%)				
1. Female	10(20)	8(16)	2(4)	0.196
2. Male	15(30)	10(20)	5(10)	
Using Glasses, n (%)				
1. Glasses	5(10)	4(8)	5(10)	0.087
2. No Glasses	20(40)	14(28)	2(4)	

Table 1 displays that 40% of ergonomic drawing tablet users in a literary writing mode are women, while 60% are men. The chi-square test findings showed a non-significant difference in the cardiovascular risk of using an ergonomic drawing tablet for writing modern characters between male and female genders, with a p-value of 0.196 (>0.05). 72% of individuals did not wear glasses, while 28% did. The chi-square test results

indicate a non-significant difference in the risk of CVS between using glasses and not using an ergonomic drawing tablet with modern character writing, with a p-value of 0.087 (p>0.05).

Statistical analysis was conducted on questionnaire responses to assess the risk of Computer Vision Syndrome (CVS) when using ergonomic drawing tablets for writing modern characters. The study aimed to determine the level of CVS risk and its correlation with the usability interface of the ergonomic drawing tablet application for writing modern characters. Usability in this study was assessed using Molich and Nielsen's heuristic evaluation method, which includes ten approaches for evaluating human-machine systems. The questionnaire aimed to examine the correlation between writing more characters and symptoms of Computer Vision Syndrome (CVS) to identify potential risk factors for CVS when using an ergonomic drawing tablet application to write more characters. 41.46% of CVS cases were identified by external ocular symptoms, 30.27% by visual symptoms, and 28.26% by internal ocular symptoms. These symptoms indicate that sensitive Computer Vision Syndrome (CVS) can occur after using the ergonomic tablet application for 3 hours or longer, leading to dry eyes, eye irritation, and eye pain. Visual problems including blurred and double vision worsen with prolonged usage of the program at work, as indicated in Table 2.

Table 2. The Mann-Whitney test was conducted to analyze the CVS symptom score based on the duration of time using the ergonomic drawing tablet application.

CVS symptoms (%)	Duration of Use Time (Hours)			p
	3-4	4-5	5<	
Internal Ocular Symptoms Eyes feel tense Pain in the eyes and around the eyes	7.82	10.22	10.22	0.047
External Ocular Symptoms Dry eyes Eyes feel irritated Burning sensation in the eyes	13.82	13.82	13.83	0.053
Visual Symptoms Double vision Blurred vision	7.82	10.22	12.23	0.002

The Mann-Whitney test results indicate a significant difference in CVS symptoms related to visual issues based on the duration of use of the ergonomic drawing tablet application, with a p-value of 0.002 ($\rho < 0.05$). This suggests that symptoms like blurred vision and double vision will worsen with longer use of the application. External ocular symptoms related to CVS with a p-value larger than 0.005 did not show a significant difference based on the duration of use of the ergonomic drawing tablet program. CVS symptoms such dry eyes, eye irritation, and intraocular discomfort are experienced equally after 3 hours or more.

The bivariate analysis showed a significant relationship between the length of work using an ergonomic drawing tablet and the incidence of CVS. The p-value was

0.028, and the odds ratio (OR) was 1.03 for 3-4 hours of work, 1.17 for 4-5 hours of work, and 1.23 for working more than 5 hours. The 95% confidence interval (CI) ranged from 1.094 to 18.503, as presented in Table 3.

Table 3. The Relationship Between Duration of Employment at Ergonomic Drawing Tablet and Incidence of Computer Vision Syndrome

Duration of Using Ergonomic Drawing Tablet (hours)	CVS		OR	95% CI	p
	n	%			
3 - 4	15	30	1.03	1.094-18.503	0.028
4 - 5	17	34	1.17		
5 <	18	36	1.23		
Total	50	100			

Table 3 indicates a significant relationship between the amount of time spent working with an ergonomic drawing tablet and the occurrence of Computer Vision Syndrome (CVS). The likelihood of developing Computer Vision Syndrome (CVS) increases with the duration of continuous work: 3% after 3-4 hours, 17% after 4-5 hours, and 23% after more than 5 hours.

A mathematical model incorporating a heuristic evaluation method is used to calculate the CVS level when using an ergonomic drawing tablet application for writing modern characters. The formula is CVS = (0.28X1 + 0.41X2 + 0.31X3) / 10. The CVS values for different working durations are 29.46% for 3-4 hours, 34.26% for 4-5 hours, and 36.28% for 5 hours or more, as depicted in Figure 3.

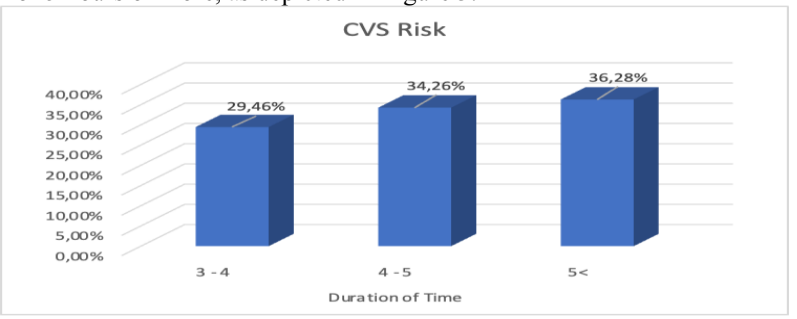


Figure 3. CVS Risks Using Ergonomic Drawing Tablet

The usability level of the ergonomic drawing tablet application interface in facilitating the writing of modern characters can be determined as 89.88% using the CVS risk value for each duration of working time. High usage of the application increases the likelihood of users experiencing CVS symptoms after working continuously for more than two hours.

The longer you work constantly using an ergonomic tablet, the higher the danger of developing Computer Vision Syndrome (CVS), as illustrated in Figure 4.

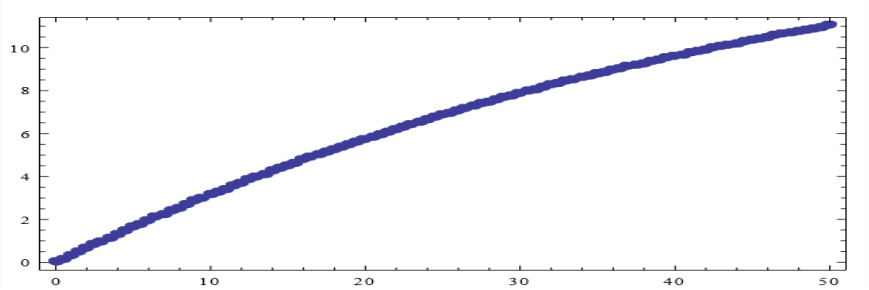
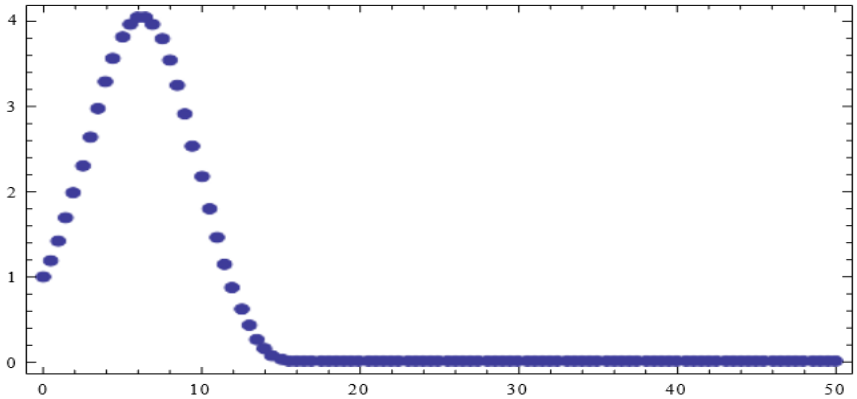


Figure 4. The Relationship between Increasing Work Duration and CVS Risk

Using an ergonomic drawing tablet for over 2 hours starts to pose a danger of Computer Vision Syndrome (CVS) at a low stage of 3%. If the user continues without taking a break, the risk of Computer Vision Syndrome (CVS) would rapidly increase to 17% or even 23%.

Each degree of CVS symptoms, such as internal ocular symptoms, external ocular symptoms, and visual symptoms, exhibits distinct characteristics. External ocular symptoms remain elevated and consistent, although visual symptoms tend to escalate in direct correlation to the length of work time. Internal ocular symptoms significantly increased within the first 1-8 minutes of administering the treatment, followed by a quick fall until stabilizing, as illustrated in Figure 5.



Figur 5. Comparison of Symptom Levels Using Ergonomic Drawing Tablets

The initial ocular symptoms experienced when using the application are a result of the eyes not yet adjusting to the light from the screen and the focus not stabilizing until around eight minutes after starting to use the program.

4 Conclusion

(1) Based on the analysis and discussion of the data, it can be concluded that the ergonomic drawing tablet UI/UX design is generally good, with a usability rating of 89.88% from the heuristic evaluation. This implies that the interface offers convenience and is user-friendly. Extended use of the application for 3 hours or more

consecutively significantly raises the user's risk of Computer Vision Syndrome from 3% to 23%.

(2) The UI/UX design of the ergonomic Drawing Tablet can significantly decrease the likelihood of experiencing internal ocular symptoms by maintaining a stable position when using the application for over eight minutes.

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