Enhancing LMS Design through SUS Analysis and Biometric Usability Testing

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***Abstract*—With the rapid advancement of e-learning platforms, especially Learning Management Systems (LMS), there have been increasing issues in achieving a seamless user experience. Although LMS are becoming integrated into the traditional education system, they often fail to meet the expectations of students and lecturers, which causes the dissatisfaction and frustration. This study examines the usability of the LMS at Mae Fah Luang University by applying both traditional System Usability Scale (SUS) surveys and refined biometric usability testing, using facial expression analysis and respiratory data collection. These dual techniques ensure to uncover the deeper knowledge into the emotion and cognitive states of the users while they are interacting with the LMS. The SUS survey showed the navigation issues and user interface (UI) complexity, with the poor usability score of 55. Biometric data analysis then emphasized and validated these findings, by revealing the negative emotions together with fluctuated respiratory patterns. SUS and biometric approach to usability testing focus on requirements of implementing an intuitive and user-friendly LMS design to improve the learning experience of the students. Recommendations encompass the information visibility, clear navigation paths and timely notification to improve overall usability of LMS.**

***Index Terms*—Usability testing, Learning Management System, Biometrics, Facial emotion analysis, Respiratory data analysis**

I. Introduction

The LMS serves as a tool for the delivery of study materials and lessons. E-learning LMS platforms have been started since 2000 [1], with a rapid surge in 2020 due to COVID-19 pandemic. E-learning platforms have been integrating into conventional classroom learning, creating the blended learning [2]. Therefore, it is becoming crucial to understand the user experience and usability of e-software and websites as usability is essential for the survival of platforms [3]. However, many e-learning platforms struggle to meet the expectations of students and teachers, which leads to frustration, inefficient use of time, and interferes with the learning outcomes.

Usability testing is traditionally performed with potential users by collecting the verbal feedback through one-on-one conversations, surveys, questionnaires and metrics. This sometimes becomes a pitfall because some users tend to give more positive feedback as they may not be sure how they feel or they might not simply want to hurt the feelings [4]. To mitigate that pitfall and to obtain a more thorough view of user engagement, facial expression analysis together with the respiratory data can detect the emotional state, cognitive load and frustration to give an additional sophisticated way to perform the usability testing.

This paper demonstrates that utilizing biometric feedback from facial expressions and respiration can offer valuable insights into the UX, pain points and emotions, resulting in LMS platform with more personalized and adaptive learning experiences.

II. Literature Review

A. Usability in Learning Management Systems

LMS is supposed to be easily learnable and usable. A well designed learning management system can encourage students for active participation leading to improved student engagement, learning outcomes and overall user satisfaction. LMS must attract students by effectively presenting its objectives. To create a higher education website, it is important to prioritize usability as a key factor [5].

B. Comparative Analysis of Traditional Usability Testing, SUS, and Biometric Methods

Traditional Usability Testing is often expensive, requiring significant amount of resources, specialized tools and several skilled usability professionals [6]. While effective to find the problems, these methods may not always be possible for all projects due to high costs and practical challenges.

System Usability Scale is a short questionnaire consisting total ten questions, including five positive questions and five negative questions. To measure usability, SUS survery is a reliable statistic method [7] however SUS survery is inherently

subjective, as it captures how users feel and perceive about the system [8].

On the other hand, biometric metric technologies testing can complement by finding the hidden issues that users may be unaware of or hesitant to report. Therefore, to address usability comprehensively, this study combines SUS survey and biometric technologies to develop the design of LMS system.

III. Methodology

The research process started from the SUS survey and biometric usability testing, followed by analysis and recommendations as shown in Fig. 1.

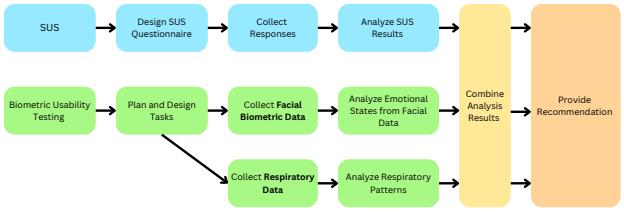


Fig. 1: Research Methodology

A. SUS Survey

The preliminary SUS survey conducted by using the Google Forms is to gain the user experience of LMS, which is an e-learning platform of Mae Fah Luang University. A questionnaire is created based on the system usability testing, together with additional demographic questions, frequency of usage and suggestions for the LMS.

Objectives:

- To evaluate and determine the overall usability of LMS.

Goals:

- To quantitatively measure the overall usability scores of LMS through SUS questionnaires
- To collect the specific issues and suggestions faced by the students while using LMS

1) Questionnaire Design: The questionnaire consists of two sections. The first section contains the profile of the respondents (e.g., age, school of study, etc.), and the second section includes a set of 10 SUS questionnaire items-5 positive and 5 negative questions by using the scales of 1-5 (strongly disagree to strongly agree) [9]. The SUS items are slightly rephrased to LMS-specific terminologies, with the intentions to align the user experience of LMS.

Question number 1,3,5,7 and 9 are the positive questions; (Q1) I think I would like to use this LMS frequently, (Q3) I thought the LMS was easy to use, (Q5) I found the various functions in this LMS were cohesive, (Q7) I would imagine that most people would learn to use this LMS very quickly, (Q9) I needed to learn a lot of things about it before I could use this LMS system.

Questions 2,4,6,8 and 10 are the negative items; (Q2) I found the LMS unnecessarily complex, (Q4) I think that I would need the support of a technical person to use this LMS, (Q6) I thought there was too much inconsistency in this LMS, (Q8) I found the LMS inconvenient to use, (Q10) I needed to learn a lot of things about it before I could use this LMS system.There is also a suggestion section so that students could express their LMS experience.

TABLE I: Demographics of the Respondents

Category	Categories	Frequency	Percentage
Age	Under 18	4	0.96%
	18-20	190	45.53%
	21-23	205	49.21%
	24-26	14	3.36%
	Over 26	4	0.96%
Gender	Male	77	18.47%
	Female	328	78.74%
	Prefer not to say	12	2.87%
Nationality	Thai students	290	69.55%
	International students	127	30.45%
School	School of Nursing	10	2.40%
	School of Medicine	1	0.24%
	School of Health Science	50	11.98%
	School of Integrative Medicine	14	3.36%
	School of Cosmetic Science	25	5.99%
	School of Liberal Arts	33	7.92%
	School of Management	126	30.22%
	School of Applied Digital Technology	51	12.22%
	School of Social Innovation	7	1.68%
	School of Sinology	44	10.55%
	School of Law	44	10.55%
	School of Agro-industry	8	1.92%
	School of Science	4	0.96%
	Total	417	100%

2) Demographic of the Respondents: The respondents in this survey are the Mae Fah Luang University undergraduate students. There are a total of around 15,269 students [10] at Mae Fah Luang University. When considering the sample size for the SUS survey, the respondents sample size is calculated based on the current student population, which results in at least 384 students. Therefore, our survey collected a total of 417 students sample sizes for SUS as shown in Table. I.

3) Experience Level and Usage of LMS: In terms of familiarity with the technology with 1 to 5 scales, Table. II illustrates that most of the respondents are comfortable with the technology. However, Table. III shows that only a few students engage with LMS on a daily basis.

TABLE II: Experience level with technology of participants

	Levels	Frequency	Percentage
Experience level	Very Uncomfortable (1)	5	1.20%
	Uncomfortable (2)	10	2.40%
	Neutral (3)	113	27.11%
	Comfortable (4)	166	39.84%
	Very Comfortable (5)	123	29.49%
	Total	417	100%

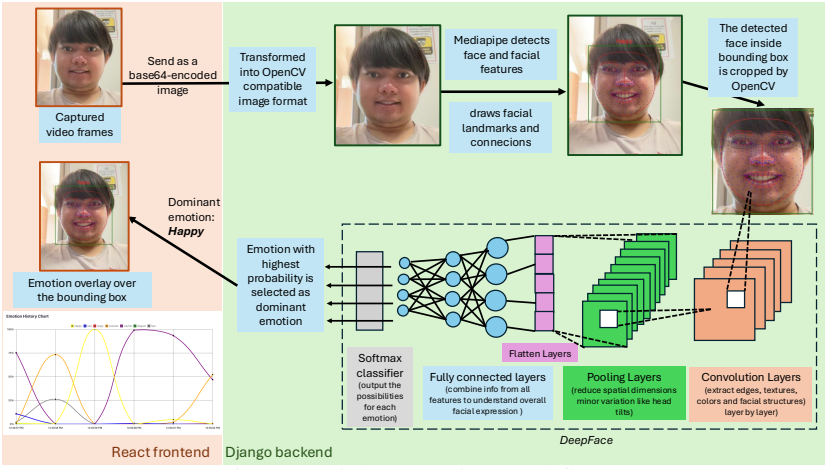


Fig. 2: Facial Expression Workflow

TABLE III: Frequency usage of LMS

	Usage	Frequency	Percentage
Frequency Usage	Rarely	134	32.15%
	Occasionally	118	28.32%
	Weekly	114	27.35%
	Daily	51	12.23%
	Total	417	100%

B. Biometric Usability Testing

1) Planning and Task Design: The usability testing is conducted after the SUS survey, with the information and suggestions gathered from the SUS survey.

The testing focused on the specific features, which students found difficult to use or navigate, and conducted using the biometric data collection methods such as facial expression and respiratory rate from the participants during the testing session.

Objective:

- To evaluate the specific areas of LMS to gain more insights into the usability issues
- To identify the complexity of the navigation and UI

Goals:

- To use the the biometric data to capture and analyze the cognitive state of participants during the tasks
- To test and validate the common usability issues received from suggestions of the SUS survey

According to the three experiment results conducted by Virzi [11], five participants were enough to uncover the major usability problems. So, six participants [12] out of 417 participants who previously participated in SUS survey collection were recruited. To avoid bias, 3 participants were international students and 3 are Thai, all from different majors. The testing was run in the study room of the Mae Fah Luang University library, which fulfilled the criteria of both being a quiet setting and being in the natural environment [13] where students use the LMS. A sound proof room with controlled lighting was used, and blackout curtains were drawn to avoid reflections from external light sources and inconsistent lighting conditions. Participants were called 15-30 minutes prior to the tests to settle in with the process and environment. A clear instruction was also given to mitigate the external factors such as anxiety and fear. Participants sat down at an arm's length distance (20-30 inches) from the computer screen, with the webcam covering the whole face. Two facilitators assisted the respiratory equipment set up on the participants and instructed them to breathe normally and to feel relaxed.

The usability testing session began by informing the participants about the purpose of the test and a consent form to sign. The test was preceded by asking participants with pre-test questions followed by the usability testing of different task scenarios as follows:

1) Task-1 Assignment submission in LMS
   - Scenario - "You took the Global Citizenship course. You want to submit the assignment and check other assignments due date"
2) Task-2 Checking the grades of a course
   - Scenario - "In Global Citizenship course, you finished all video quizzes. So you want to see the scores."
3) Task-3 Checking the project group and members
   - Scenario - "In the Global Citizenship course, you did not know which project group you belong. So you search for your group number in the LMS."

The three task scenarios were written based on the core features of LMS, which mostly appeared in the suggestions section in SUS survey. The testing was followed by the post-test questionnaire at the end.

2) Facial Biometric Data Collection: The system deployed on local server (See Fig. 2) started with the react-webcam library streaming the video of the webcam to the *React* front-end. The video frame images, captured at the interval of one frame per second from the webcam, will be sent to the back-end server of *Django* framework, where *OpenCV* [14] transforms and preprocesses the images into the *OpenCV* (v4.10.0) compatible format for further processing. *Mediapipe*

(v0.10.18) can detect the 468 facial landmarks [15] on predefined regions of the face such as the mouth, eyes and eyebrows. After detection and identification, these facial features will be extracted to analyze the detailed movements, forehead wrinkles or eyebrow raises, etc. Then, extracted features will be classified into the corresponding 7 basic dominant emotions; "happy", "angry", "sad", "neutral", "disgust", "fear" and "surprise" [16] by the VGG-Face model of *DeepFace* (v0.0.93) which has the accuracy of 97.40% [17], then finally compiled into a data visualization chart report.

3) Respiration Biometric Data Collection: The respiratory belt measured the change in circumference of the torso of the participants [18]. Vernier Graphical Analysis software was used to detect the respiration force and rate of participants to be documented and stored on the software. Then, the faulty values of respiratory rate (BPM) data was cleaned by linear interpolation. To minimize the noises in the data, a moving average filter was used. After the processing was finished, it displayed the plot as in Fig 3. This was concluded to know different emotional stages the participants' faces throughout the test.

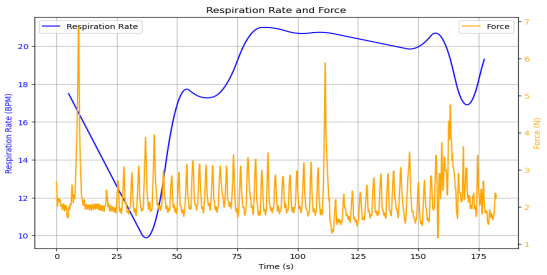


Fig. 3: Respiratory Force and Rates (BPM)

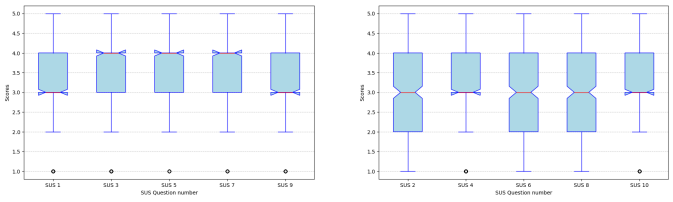
C. Ethical Considerations

To ensure that user privacy, data security and informed consent are diligently protected, participants must fully understand how their data will be collected, stored and used. It is crucial to obtain specific consent from participants and to clearly communicate the purpose and scope of the testing [19]. Before the usability testing sessions, the consent and information paper of what will be covered during the testing session will be given to the participants together with informing that they can leave during the testing if they are not comfortable anymore. Biometric data are stored securely, with strict access controls only accessible to the researchers, which outside people and people without access cannot receive the information. In terms of data retention and disposal, all the recording data will be kept only for the duration of the research.

IV. Results

A. SUS Results and Data Analysis

The scores of each SUS questions can be seen in Fig. 4. The overall usability score calculation is structured as follows: X represents the number of 5 subtractions from the sum of points for all odd-numbered questions and Y will be the number of the sum of points for all even-numbered questions subtracted from 25. Continue to calculate use the formula of (X+Y)*2.5. For the LMS System, the overall score is 55, rounded from 55.05 (See Fig. 5). To interpret the SUS score and evaluate the system's effectiveness and efficiency, the result falls into the "Poor" category [20], indicating that the LMS system needs improvement.



(a) Positive SUS items (b) Negative SUS items

Fig. 4: Box-and-Whisker plot of the scores of the 10 SUS statements

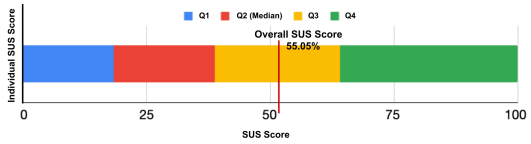


Fig. 5: Overall SUS Score compared to individual SUS score quartile range

B. Biometric Data Analysis

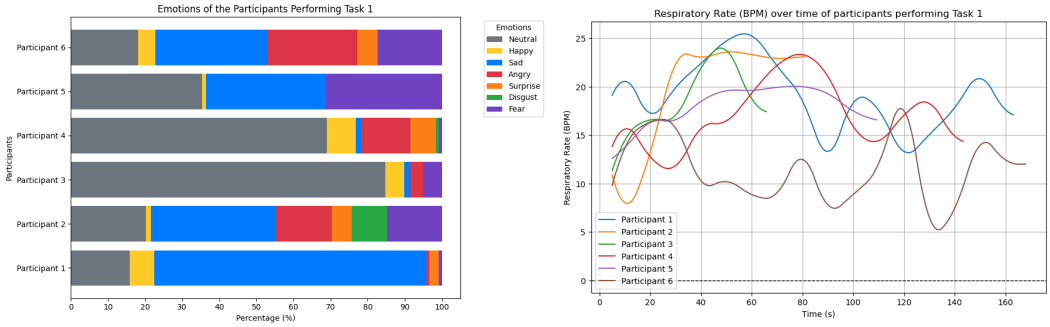
All of the three tasks reflect the real-world realistic usage [13] of LMS and the common problems raised by the participants from the SUS survey. Prior to the usability testing sessions, all six participants were given a set of pre-test questions to receive the detailed demographical information, shown in the Table. IV.

TABLE IV: Demographics of the six participants

Participants(P)	Major	Year	LMS usage
P1	Nursing	2nd	Rarely
P2	Business Administration	3rd	Rarely
P3	Software Engineering	1st	Daily
P4	English	3rd	Rarely
P5	Business Chinese	3rd	Rarely
P6	International Development	3rd	Rarely

1) Task 1 : Assignment submission: As shown in Fig. 6, P1, P2 and P6 share the dominant negative emotions 'sad', 'angry' and 'fear' together with high and fluctuating respiratory rates in all three of them, showing the emotional distress and cognitive overload during the testing session [21]. P5 showed an almost equal amount in 'neutral', 'sad', and 'fear' with a steady trend in the BPM.

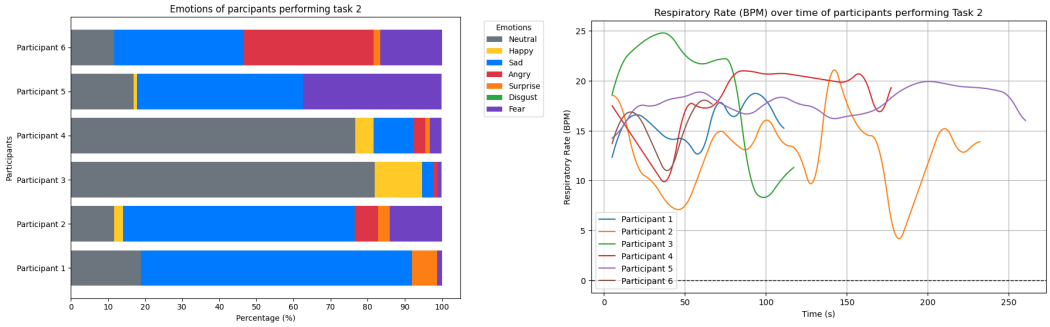
With the shortest time to complete the task, P3 was the only one with an higher percentage of 'neutral' emotion with a steady rise in BPM without sudden spikes, which suggest that they remained calm and at ease performing this task. Another participant with the dominant 'neutral' emotion is P4 with the steady rise and fluctuations towards the end. During the



(a) Frequency of Emotions during Task 1

(b) Respiratory Rate (BPM) during Task 1

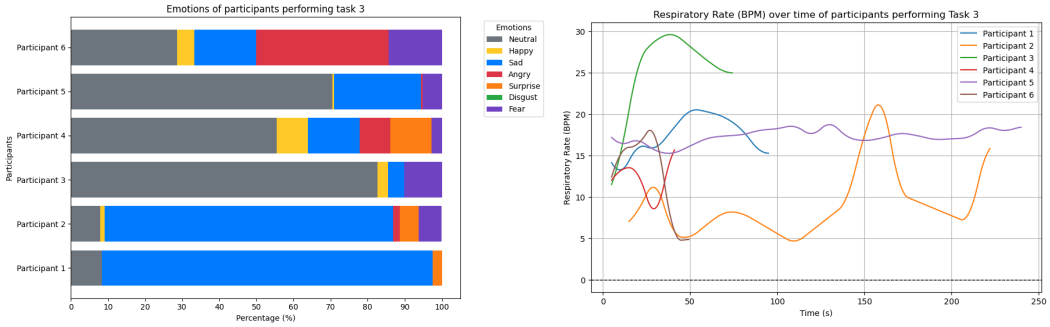
Fig. 6: Task 1 Analysis: Emotions and Respiratory Rate



(a) Frequency of Emotions during Task 2

(b) Respiratory Rate (BPM) during Task 2

Fig. 7: Task 2 Analysis: Emotions and Respiratory Rate



(a) Frequency of Emotions during Task 3

(b) Respiratory Rate (BPM) during Task 3

Fig. 8: Task 3 Analysis: Emotions and Respiratory Rate

same time period with these fluctuations, the highest emotions observed were 'surprise' and 'happy'. It can be deduced that the participant found it exciting and engaging when they finished up the task. Follow-up interview questions revealed the experience of using the LMS for 4 out of 5. However, P3 was the only one who expressed similarly with their biometric results. The rest of the participants found it less engaging and showed signs of emotional distress.

2) Task 2 : Checking Grades of Global Citizenship Course: The presence of predominantly 'sad' in P1, P2, P5 and P6 correlates with the elevated and/or erratic breathing patterns [21], revealing the emotional stress or cognitive overload while navigating the scores of LMS. The respiratory rates of all four participants highlights the increasing trends over time. This might be interpreted that the emotional stress or frustration escalated as they struggled to complete the task. However, P3 and P4 showed primarily 'neural' emotion state, which may represent lower emotional distress or less engagement during the activity. Only P6 could complete the task with the minimal time of 55 seconds, while the other participants could not complete the tasks due to usability and navigation challenges. (See Fig. 7)

The participants rated either 1 or 2 a scale from 1(poor) to 5(excellent) for the tasks (except P6 who completed the task gave a rating of 3).

3) Task 3 : Checking the project group: After completing the task 3, (See Fig. 8) P1, P5 and P6 rated the experience as 3 while P2,P3 and P4 rated 2,4, and 5 respectively. Five participants responded positive navigation experience while one participant reported it as hard to navigate. Despite their

positive verbal ratings, the biometric testing results showed differently. The emotional results of all participants showed no signs of satisfaction, even though most of them provided positive ratings.

According to the emotion graph, two participants had 'fear' dominant emotions, three had 'neutral' emotion and one displayed 'angry'. The respiratory results highlighted common points of dissatisfaction. Three participants experienced their highest BPM when they could not find their own names while the other three reached their highest BPM when the group section was not placed where they expected. The negative emotion of 'fear' and 'angry' correlates with the fast and high BPM, and vice versa [21], which showed emotional distress and cognitive overload.

V. Conclusion

The study conducted the SUS survey and the biometric usability testing on LMS and demonstrated that LMS lacks the basic usability, which lead to struggle in completing the tasks during the usability testing. SUS survey pointed out the lower mean SUS score [20] of 55 and complex user interface and navigation as common issues. These were reflected in the biometric data, where participants exhibited high level of negative emotions such as sadness, fear and anger, together with high and erratic respiratory patterns. This double-checking approach with both SUS questionnaires and biometric data emphasized the importance of reducing cognitive load and providing user-friendly interface for LMS platform. Based on the findings from the post-test follow up questionnaire and users' navigation throughout the testing, it is recommended that all the essential information such as grades and group number of students needs to be easily accessible and visible to avoid confusion and cognitive overload. LMS should be visually appealing with vibrant color. Additionally, timely notification system of assignment and exam due dates is critical. Although this usability study disclosed the usability pain points of LMS, there are some limitations which need to be addressed and acknowledged for further study and future works. Firstly, this study only covers the perspectives of students while it did not include the lecturers' perspectives on usability of LMS. The testing of the all three tasks involved in this study may not be the whole representation of all the features of LMS platform. More tasks could yield the different findings in terms of students' cognitive load, emotion state and task completion. Lastly, facial expression might sometimes be challenging to interpret as some students may have the resting neutral or smiling faces without obviously showing the certain emotion even in the emotion distress. Therefore, future survey should integrate the heart rate detection and/ or eye tracking of participants on the screen through the test, which ensures the accuracy of biometric data more significantly.

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References

[1] S. Niaz, S. Memon, and S. Khokhar, "Development of e-learning: A historical review with global perspective," *International Research Journal of Arts & Humanities (IRJAH)*, vol. 49, no. 49, 2021.

[2] A. Baquero and R. Escortell, "Blended learning: A new trend in education," in *ICERI2022 Proceedings*. IATED, 2022, pp. 4484–4491.

[3] J. Nielsen *et al.*, "Usability 101: Introduction to usability," *Nielsen Norman Group website*, 2012.

[4] T. D. Abel, "Beyond usability: Methodologies and bias – surveying the surveys," in *Universal Access in Human-Computer Interaction. Theory, Methods and Tools*, M. Antona and C. Stephanidis, Eds. Cham: Springer International Publishing, 2019, pp. 3–12.

[5] M. Manzoor, W. Hussain, A. Ahmed, and M. J. Iqbal, "The importance of higher education website and its usability," *International Journal of Basic and Applied Sciences*, vol. 1, no. 2, pp. 150–163, 2012.

[6] J. Scholtz, "Adaptation of traditional usability testing methods for remote testing," in *Proceedings of the 34th Annual Hawaii International Conference on System Sciences*, 2001, pp. 8 pp.–.

[7] K. Orfanou, N. Tselios, and C. Katsanos, "Perceived usability evaluation of learning management systems-sus," *The International Review Of Research In Open And Distance Learning*, vol. 16, no. 2, pp. 227–240, 2015.

[8] P. Kortum and S. C. Peres, "The relationship between system effectiveness and subjective usability scores using the system usability scale," *International Journal of Human-Computer Interaction*, vol. 30, no. 7, pp. 575–584, 2014.

[9] J. Brooke, "Sus: A quick and dirty usability scale," *Usability Eval. Ind.*, vol. 189, 11 1995.

[10] Mae Fah Luang University, "Current student statistics," 2024, accessed: December 9, 2024. [Online]. Available: https://stat.mfu.ac.th/current-student-stat

[11] R. A. Virzi, "Refining the test phase of usability evaluation: How many subjects is enough?" *Human Factors: The Journal of Human Factors and Ergonomics Society*, vol. 34, pp. 457 – 468, 1992. [Online]. Available: https://api.semanticscholar.org/CorpusID:59748299

[12] N. Bevan, C. Barnum, G. Cockton, J. Nielsen, J. Spool, and D. Wixon, "The" magic number 5" is it enough for web testing?" in *CHI'03 extended abstracts on Human factors in computing systems*, 2003, pp. 698–699.

[13] J. Rubin and D. Chisnell, *Handbook of usability testing: How to plan, design, and conduct effective tests*. John Wiley & Sons, 2011.

[14] J. Howse, P. Joshi, and M. Beyeler, *Opencv: computer vision projects with python*. Packt Publishing Ltd, 2016.

[15] N. Kumar Rao B, N. Panini Challa, E. S. P. Krishna, and S. S. Chakravarthi, "Facial landmarks detection system with opencv mediapipe and python using optical flow (active) approach," in *2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)*, 2023, pp. 92–96.

[16] H. Sheng and M. Lau, "Optimising real-time facial expression recognition with resnet architectures," *Journal of Machine Intelligence and Data Science (JMIDS)*, vol. 5, no. 1, pp. 33–45, 2024.

[17] A. Awana, S. V. Singh, A. Mishra, V. Bhutani, S. R. Kumar, and P. Shrivastava, "Live emotion detection using deepface," in *2023 6th International Conference on Contemporary Computing and Informatics (IC3I)*, vol. 6, 2023, pp. 581–584.

[18] A. Kristoffersson and M. Lindén, "A systematic review of wearable sensors for monitoring physical activity," *Sensors*, vol. 22, no. 2, p. 573, 2022.

[19] I. T. Ketley, "Case study: Code of ethics for facial recognition technology," *Proceedings of the Wellington Faculty of Engineering Ethics and Sustainability*, 2022.

[20] T. Will, "Measuring and interpreting system usability scale (sus)," *UIUX Trend*, 2017, accessed: Dec. 6, 2024. [Online]. Available: https://uiuxtrend.com/measuring-system-usability-scale-sus/

[21] A. A. Sarkar, "Functional correlation between breathing and emotional states," *MOJ Anatomy & Physiology*, vol. 3, no. 5, pp. 157–158, 2017, received: March 14, 2017; Published: May 18, 2017.