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Eye gaze modeling using Tobii eye tracker for anxiety and mental health detection on Politeknik Negeri Jember student: A case study

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Abstract

Education development is one of United Nation (UN) sustainable development goals (SDGs) number 4 program, where Indonesian ministry of education designed new education curriculum in 2019. Merdeka Belajar program is comprised of certified internship and independent study, which often became a graduation requirement especially for engineering major. However, rapid change in curriculum frequently caused disruption on student concentration that leads into decline in learning motivation and raising anxiety symptom. This research aims to monitor engineering students' anxiety during courses. Anxiety-ridden students perform poorly on assignments and have a mediocre interest in studying. The eye gaze can be linked with stress level. Its pattern reflects the anxious state that befalls engineering students. Our paper's primary contribution is offering an observational result on how to use eye gazing to address the anxiety that engineering students experience by observing students' eye movements. The 16 zones (1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d, 4a, 4b, 4c, 4d) make up the eye gazing pattern. 53.8% of the

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student experience moderate anxiety, while 26.1% of respondent suffers severe anxiety. The research's accuracy rate is 85.5%. These findings offer recommendations for how teachers might quickly assess students' anxiety levels and take specific action to support students in achieving their best learning outcomes.

Keywords: *Eye gaze, Anxiety, Mental health, Education*

1. Introduction

Education development is covered in UN SDGs 4 program due to its importance for better future (Reimers, 2024). Indonesian ministry of education develops new education curriculum in 2019 to match UN goals, which emphasised independent learning where student is able to convert conventional subject into *Merdeka Belajar* program through certified internship and independent study especially for engineering major (Marjan, Tuti, F & Aswita, 2021)(Christwardana *et al.*, 2022). Those program often conducted via on-line (Agustianto *et al.*, 2016). However, rapid change in curriculum often caused student concentration disruption leading into decline in learning motivation and raising anxiety symptom.

One important aspect that engineering students typically encountered while studying was the anxiety/mood disorders (Vitasari *et al.*, 2010a). AESs, or adaptive educational systems, were introduced by Gaudioso et al. (Gaudioso, Montero and Hernandez-del-Olmo, 2012) to assist students in selecting appropriate course material. Thus, anxiety becomes a problem that needs to be addressed in higher education. In order to help students avoid failure and achieve success through their studies, Destarianto et al. (Destarianto, Etikasari and Agustianto, 2018) encouraged students to model their own motivating systems (Dewanto, Agustianto and Sari, 2018).

A mood condition can impede one's ability to study as well as negatively impact social and physical well-being (Cybulski *et al.*, 2020a). The platform of the educational system has changed as a result of e-learning, which replicates study through an online platform. The internet serves as the main conduit for instructional information delivery in online learning (Reinig, 2010; Allen *et al.*, 2016). With the help of this technology, human limitations in terms of space, time, and flexibility can be eliminated.

This study uses student eye movement patterns to discover strategies for addressing the anxiety of engineering students face when using eye gaze. 1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d, 4a, 4b, 4c, and 4d are the sixteen zones that make up the eye gaze pattern. The coordinates of the points are selected for each area that has been determined and then grouped into two primary regions: inside and outside. 1b, 1c, 1d, 2b, 2c, 2d, 3b, 3c, 3d, 4b, 4c, and 4d are the outer areas, whereas 1a, 2a, 3a, and 4a are the inner ones.

2. Literature review

Responsible technology defined as breakthrough or innovation to make people happier (Jirotka and Stahl, 2020). The need for reliable technology such as Artificial Intelligence

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(AI) and big data to the education process has shown the closed interaction between humans and technology. Additionally, by continuously monitoring students who are at a high risk of abandoning the course, online learning can also track early dropout rates. Recognising the problem that students are having while they learning can also be helpful (Coussement *et al.*, 2020). To evaluate accomplishment and clarity, the Logit Leaf Model (LLM) were employed. Due to the challenging nature of the courses in the engineering sector, every student at an engineering faculty needs to be enthusiastic about their studies. Monitoring student motivation is crucial to preserving their output. They employ a plan-based strategy and utilise a mentor role model (López-Fernández *et al.*, 2019a).

In situations where there is a lot of work to be completed, like an initial planetary mission plan, engineering faculty members find it difficult to keep their students motivated (López-Fernández *et al.*, 2019b). Referring to Fig. 1, the other study focusses on examining how the arrangement of the classroom may impact students' learning experiences. Scholars investigate the relationship between students' engagement with their learning environment and their academic achievement (Byers, Imms and Hartnell-Young, 2018). The other researcher concentrated on enhancing learning behaviour through an enhanced e-book system connected to social media platforms like Facebook in order to increase students' motivation. They examine the student's comments in the e-book system and behavioural patterns (Zarzour, Bendjaballah and Harirche, 2020a). According to their findings, pupils with low engagement rates should be encouraged. The integration of social media and educational platforms has been observed to increase students' purported level of interaction. By sharing, like, or submitting their opinions on the system, they exhibit their likeness (Zarzour, Bendjaballah and Harirche, 2020b). The researcher affirms that students' use of digital information technology has resulted in more effective learning outcomes. According to their research, common talents are very encouraging (Hernández-Lara, Serradell-López and Fitó-Bertran, 2019). based on a critical evaluation of earlier research in the field of e-learning and its relationship to human accomplishments. According to Table 1 for an overview, we may infer that there is a strong association between the e-learning system and student behaviour analysis as responsible technology to aid students in particular, or mankind in general.

Table 1. *E-learning analysis as responsible technology*

Authors	Finding	Correlation with responsible technology
[7, 8]	E-learning is a technology to overcome the	E-learning has a significant factor in boosting student performance.

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Authors	Finding	Correlation with responsible technology
	limitlessness of humans in terms of time, place, and suppleness.	
[11]	Improve motivation of engineering student	E-learning analysis may help in detecting students that already bored and less focused.
[13]	Utilize social media to attract student active engagement	Assimilation between social media and e-learning increase student participation.
Proposed approach	Early anxiety detection through eye gaze model	Eye gaze technology and e-learning have a strong correlation as responsible technology to capture student attention during the learning process.

Adult cases of temperamental disorders are on the rise and have become widespread crises in public health; the likelihood of experiencing a period of depression increases with age. As a result, anxiety becomes a problem in higher education that requires treatment. Existing research indicates a substantial correlation between advanced stress and student failure, despite the fact that significantly higher education techniques have a higher capacity for anxiety (Cybulski *et al.*, 2020b). Studying children's eye look during times of fear during the learning process is another way to focus on their learning (Michalska *et al.*, 2017).

The brain is the source of human emotion, and people express their emotions through their eye movements. Their body's physiological status and inner feelings are reflected in their eyes (Ntonia and Ntonias, 2006). Perceptions of one's gaze are crucial in social anxiety disorder (SAD) identification. When a subject withdraws from eye gaze in a social anxiety scenario, it may be a sign that they are uncomfortable being assessed because they perceive a danger (Schulze, Renneberg and Lobmaier, 2013). The student's overall achievement in the engineering area is reflected in the anxiety that results from their encounters. It may have an impact on students' engagement, curiosity, or cognitive ability (Carberry, Lee and Ohland, 2010; Vitasari *et al.*, 2010b, 2011). The other researcher concentrated on measuring the impact of anxiety level on engineering students

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through a survey utilising statistical analysis. Additionally, they suggested engaging in strenuous activities to overcome anxiety (et al., 2019).

Optimum education process can be achieved through understanding effect of anxiety level on engineering student. Anxious student will be less interested in studying; where it links to increase of stress level, which has severely inhibited studying process (Holmes, Richards and Green, 2006). This study uses eye gazing to identify anxiety. Eye movement has direct link to an individual's phobias (Grillon, Riquier and Thalmann, 2007), where Computer Graphics and Animation (CG&A) and eye-tracking device were employed to examine cognitive and psychological behaviour (Subrahmaniam, 2013).

Previous study confirm correlation between eye gaze data obtained with high-level tracking device with subject behavior and psychology during interaction. In addition, eye gaze was used to measure students' stress levels and track how they felt about their education (Jyotsna and Amudha, 2018; Agustianto *et al.*, 2022). In addition, the study conducted by Wang uses eye gaze to identify bias in anxiety judgements derived from facial expressions (Wang and Yue, 2011). A person's emotions and cognitive abilities will be distressed by the signal from their body (Rehg *et al.*, 2013). The other researcher uses Role-Sphere Influence to assess their failure and behaviour while also offering a personalised learning model (Firdausiah Mansur, Yusof and Basori, 2017, 2019; Basori *et al.*, 2019). use Tobi, a device that reads students' eye gaze, to evaluate the emotional and anxiety states of the students. The student's eye gaze is then classified into 16 segments, and the anxiety level will be determined by analysing the focus spots of the eye gaze. This study distinguishes between anxiety and non-anxiety anxiety classes to observe eye gaze correlation with anxiety level of student. The result is expected to promptly detect anxious engineering students.

3. Method

The study's dataset was acquired through the identification of students' eye movement patterns. Following that, the eye gaze pattern was split into 16 parts of the monitor screen (represented by the X and Y values): 1a, 1b, 1c, 1d, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d, 4a, 4b, 4c, and 4d. The monitor's resolution was 1365 x 767. The region boundaries are illustrated in Fig. 2 below.

There are two primary divisions within the defined area: inner and outside. 1b, 1c, 1d, 2b, 2c, 2d, 3b, 3c, 3d, 4b, 4c, and 4d make up the outer region, whereas 1a, 2a, 3a, and 4a make up the inside space.

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The X and Y values for those component are shown in Table 2. Take area 1a, for instance, where the Y value is between 192 and 395 and the X value is between 351 and 687 (Fig. 3).

Table 2. *X and Y values of each area.*

Area name	X values	Y Values	Area
A-1	351 – 687	192 – 395	Inner area
A-2	351 – 687	1 – 191	Outer area
A-3	1 – 350	192 – 395	Outer area
A-4	1 – 350	1 – 191	Outer area
B-1	688 – 1030	192 – 395	Inner area
B-2	688 – 1030	1 – 191	Outer area
B-3	1031 – 1365	192 – 395	Outer area
B-4	1031 – 1365	1 – 191	Outer area
C-1	688 - 1030	396 – 583	Inner area
C-2	688 - 1030	584 – 767	Outer area
C-3	1031 - 1365	396 – 583	Outer area
C-4	1031 - 1365	584 – 767	Outer area
D-1	351 - 687	396 – 583	Inner area
D-2	351 - 687	584 – 767	Outer area
D-3	1 - 350	396 – 583	Outer area
D-4	1 - 350	584 – 767	Outer area

4. Findings and discussion

In this part, present the research findings and discuss them by elaborating and corroborating with other studies and evidence. In this part, present the research findings and discuss them by elaborating and corroborating with other studies and evidence. (Table 1).

As seen in Figs. 4 and 5, we use the WebGazer (Papoutsaki *et al.*, 2016) to track users' eye gaze via webcam during the experimental investigation. WebGazer makes use of an easy-to-use eye gaze focus 3D game. Figure 5 shows the user fully focused on the 3D objects, with their face marked by a green rectangle. Figure 4 shows tracking process outcome when the user fails to pay attention.

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The anxiety detection process begins with an area classification of each percentage value. In case the percentage figure is <25, the area will receive a zero value from the system. When the algorithm locates an area with a percentage value >25, values of the inner and outer sections is summed. The system will determine the absolute value of the difference between the inner and outside areas using Eq. (1). where the difference between the inner and outer area is represented by (Δ).

The ratio of the S value to the total cost of the inner and outside region will then be determined by the system. Computed using the previously given Eq. (2). S is the absolute value of the difference between the inner and outer areas, and P is the ratio of S value to the total value of the inner and outside area. The last stage involves determining the respondents' level of anxiety. For the P-value, the machine would choose a few options that were restricted. It would identify the respondent as being anxious if the P-value was less than ten. For the P-value, the machine would choose a few options that were restricted. It would identify the respondent as being anxious if the P-value was less than ten. However, the algorithm would not detect worry if the p-value was greater than 10. Counting the dominance of the eye gaze that pointed to each location is the overall goal of the computations. The total amount of data processed for this anxiety detection is shown in Table 3. There are 23.560 total data points. There were about 280 pieces of information for every respondent that participated.

The respondent's eye was roughly 100 cm from the monitor screen during the 30-minute data collection period. The study's data variance is depicted in Figure 6 below. The study's respondent is shown on the x-axis of the graph, and the quantity of data collected is shown on the y-axis.

Table 3. *The implementation of system and device.*

Resp.	Dist.	Dur.	Numbers of data
1	100cm	30 minutes	299
2	100cm	30 minutes	293
3	100cm	30 minutes	275
4	100cm	30 minutes	273
5	100cm	30 minutes	284
6	100cm	30 minutes	284
7	100cm	30 minutes	295
8	100cm	30 minutes	285
9	100cm	30 minutes	298
10	100cm	30 minutes	300

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Resp.	Dist.	Dur.	Numbers of data
.			.
.			.
.			.
81	100cm	30 minutes	292
82	100cm	30 minutes	290
83	100cm	30 minutes	283
Total			23.560

A psychologist evaluated the technology for detecting anxiety. 65 students were used in the psychologist's investigation into anxiousness. 35 of the 65 respondents got moderate anxiety while other 26.1% suffers severe anxiety, those results from the system evaluation were compared to the psychologist's analysis result, with an accuracy score of about 85.5%. The results of the psychologist's system examination are displayed in Table 4. The discrepancy between the system's and the psychologist's detection results may be the result of different factors being employed. In addition to eye gaze, the psychologist may consider a number of additional variables that he is aware can affect anxiety in order to determine the conclusion of detecting anxiety.

5. Conclusion

The purpose of the study was to identify engineering students' anxiety during their studies. A teacher may be able to detect a student's anxiety on early phase and use that information to aid them. An eye-tracking gadget and the WebGazer program were the instruments employed in the identifying process. The main goal of this study is to make students more conscious of their anxiety and offer them strategies for overcoming it so they may perform at their best. The findings of the dominance of eye movements are examined in order to carry out the detecting process. Respondents can be classified as focused or unconcerned if their eyes are more frequently directed towards the interior space than they are towards the exterior. 53.8% of the student experience moderate anxiety while others 26.1% suffer severe anxiety. The outcome was assessed by contrasting its output with the expert psychologist's analysis. This comparison's findings yielded an accuracy percentage of 85.5%. As a result, the findings offer an alternative viewpoint on how educators could recognise students anxiety levels at early stages. Next, present a policy designed to assist students in achieving their maximum potential. In the future, physiological sensors like heartbeat or sweat sensors may be used in research projects to record physiological signals from students.

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