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Stress Detection and Mitigation through Discovery of Optimal Lecture Delivery Method for STEM-enrolled University Students

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ABSTRACT

The high availability of technology-related jobs is currently not fulfilled by enough supply of technology graduates, specifically the ones coming from science, technology, engineering, and mathematics (STEM) courses. This is related to the low enrolment rate of STEM-based courses at Universities. The notion that STEM subjects are intense and difficult to pass could be the reason of such phenomena. This research experimented different lecture delivery methods comprising of different seating arrangements, inclusion or exclusion of break, group size, and room size to investigate the generated levels of stress among STEM students, so that the method that would induce minimum stress could be discovered. The analysis of the generated heart rates as stress indication concludes that the level of difficulty of STEM subject's topic is the one that most affected students' level of stress, while inclusion of break during class is imperious to destress students. Class arrangement with far seating was discovered to be potentially more stressful for certain students indicated by the high level of resting heart rate in one of the experiments. Importantly, it was also found that regardless of lecture delivery method, STEM subjects in general remained challenging that was suggested by the consistently high recorded heart rates, which was also a sign of active learning engagement - besides implying the level of stress. Finally, gender-wise, there is no visible data pattern that could hint that certain gender is more vulnerable to stress when handling STEM subjects.

1. Introduction

Science, technology, engineering, and mathematics (STEM) subjects have been surmised as challenging and stressful. Thus the low enrolment rate in STEM-infused courses [1]. With proper treatment, stress is preventable and can be relieved. A physiological indicator of stress condition is heart rate – measured in beats/minute (BPM) [2]. For adults aged 15 years old and above, the resting

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heart rate is between 60 BPM and 100 BPM. Any heart rate above 100 BPM is considered fast heart rate a.k.a. Tachycardia [3]. Rapid heart rate causes the heart to pump less blood to organs and consequently they may not receive enough oxygen. Lack of oxygen may disturb cognitive performance [4], which may subsequentially affect the percentage of Course Learning Outcome achievement among students [5]. Several researches regarding stress management among students have been conducted, specifically involving heart rate detection where rapid heart rate indicates bodily response to stress. The recent literature presents methods that have been implemented to manage stress among students, which are meditation, music, familiarity of doing exam, and debriefing. However, lecture delivery method has not comprehensively been evaluated to mitigate stress among students.

Most related researches worked on stress detection and rarely included stress mitigation and prevention. For examples, a research to asses students' level of stress during lecture, oral presentation, and exam [6], a similar work but exam-oriented in order to study relation between change in heart rate and heart rate variability (HRV) in periods before exam, during exam, and after exam [7], a simulation-based medical research to find the relation between heart rate and level of stress in nursing practice [8], a similar medical simulation to reveal correlation between self-reported stress before and during simulation in the case of critical illness [9].

There are few related works that involved stress mitigation and prevention, such as a research about Active Learning (AL) using multiple discussions among students in lecture session [10] and a research that compared the effects of music and meditation on stress [11].

Based on understanding the importance of maintaining a healthy level of heart rate and cognitive performance, this research proposal puts forward the potential of optimal lecture delivery method to minimize or prevent stress among students since the previous related works have not digged into this mitigation niche. Subsequently, less stressful lecture may help students grab the taught knowledge, which is one of the general goals of education itself.

2. Related Works

Research related to heart rate based stress detection among students has been sporadically conducted, however is still containing gap, especially in the area of stress mitigation method that embraces lecture delivery method.

A faculty has done a work on assessing level of stress among students who did surgical and biology courses [6]. The students were assessed at different situations i.e. during lecture, during exam, waiting for exam result, listening to oral report presentation, waiting for oral presentation turn, during oral presentation, after oral presentation, and coin harvesting contest with varied water temperatures. Fast heart rates above 100 BPM were recorded during exams, during oral presentations, and during coin harvesting contest in cold water. However, the grades or marks of the exams and presentations were not mentioned. This is a significant missing information from this research since grades or marks may imply whether the stress had affected the students' performances. The findings themselves infer that challenging situations tend to incur stress among students. And we argue that when students are placed in a conducive lecture delivery method, their chance of getting stress may be reduced, therefore their cognitive ability to absorb knowledge may improve, and afterwards, this may lead to better performance in exams. Another gap in this related work is that there is no stress mitigation being included.

A research about Active Learning (AL) as a lecture delivery method was done [10]. The authors argue that multiple discussions among students themselves during lecture may reset students' attention span and give them better retention of lecture material. They measure students'

engagement according to heart rate; higher heart rate signifies engagement in AL, while lower one suggests otherwise, although the heart rates of engagement are not as high as the ones related to stress; they are still well below 85 BPM. Overall, they observed that heart rate decrease towards the end of lecture. This may be due to comfort induced after the AL sessions. They also found that 5-10 minutes breaks in lecture did not reset heart rate. Another method used was short video presentations that managed to lower students' heart rates, however, their heart rates came back up to the previous levels right after the videos finished. The drop of heart rate during video presentations may be caused by the previous experience of relating watching video and relaxation. This work has a limitation in the sense that only two (2) lecture delivery methods were involved (AL with discussions among students and short video presentation). Another gap is that the work also did not include heart rates measurements during exam and the corresponding marks or grades.

A research comparing the effects of music and meditation treatments on reducing stress was done [11]. The initial hypothesis assumed that music would have more effect than meditation, but the empirical result concludes the otherwise. Ten (10) students' heart rates and alpha wave frequencies were measured before and after treatments. While for the stress induction before the treatments, it was simulated using Stroop Test. The gaps in this research exist where the two different treatments were conducted within the same day and close to each other. Also, the alpha wave detection devices could be quite costly. This work also focuses on students' personal activities to reduce stress - instead of lecture delivery method, which is out of the scope of this referenced work.

A related work studied relation between change in heart rate and heart rate variability (HRV) in periods before exam, during exam, and after exam [7] among students in a public University in Lebanon. The authors even hypothesized that exam-induced stress may have an impact on heart health, which makes such stress management research the all important. Ninety (90) students' heart rates were measured 1 hours before exam, 2 hours during exam, and 1 hour after exam. The average heart rate before exam was significantly higher (110.93 BPM) than the other 2 periods, while the average heart rate after exam was the second highest at 104.98 BPM. And the average heart rate during exam was at 93.99 BPM, which is not far different from the estimated heart rate during active learning engagement that is below 85 BPM [10]. This decreased heart rate during exam could be caused by the students becoming familiar with the exam circumstances. It was also discovered that females suffered from higher heart rates along the 3 periods (more stress) and they took longer time to recover to lower heart rates as well. This may imply that females are more vulnerable to stress. There is a huge research gap in this study as it only focused on heart rate and stress detection, while the stress mitigation or management was excluded.

A simulation-based social research was completed to uncover the relation between heart rate and level of stress during nursing activity [8]. The 74 participating nursing students were given a simulation scenario, where a patient who was represented by a manikin had undergone a tracheal tube removal. The simulation was comprised of 5 phases i.e. Introduction/Briefing, Break, Patient Care, Reporting, and Debriefing. The findings showed that in average, heart rate peaked sharply from the break phase to the patient care phase (67 BPM to 128 BPM). Similar hike was observed during the transition from the break phase to the reporting phase (65 BPM to 136 BPM). The findings were further emphasized by the interview result, where 55 students confessed being stressed out throughout the simulation; an additional major stress factor was the presence of teachers and nursing staff who attended the simulation. This may signal that the feeling of being judged may cause discomfort at work. The authors also add explanation that McEwen and Yerkes-Dodson's laws mention that stress may downgrade work performance, therefore they suggest conducive treatment for students, such as the Debriefing that managed to bring down students' heart rates. They also advise to promote 6 breaths per minute breathing technique as another way to destress. Destressing

is critical among medical workers since those who suffer from high level of stress during simulation are more likely to make miscommunication and give incorrect dosing [12] [13]. The gap in this work is that it is only applicable for nursing students, except the 6 breaths per minute breathing technique that can be applied in most case studies related to stress.

A similar simulation-based case study in medical area has been delivered [9]. It studied attempted to find out the correlation between self-reported stress before simulation and high heart rate during simulation. The simulation revolved around scenario resuscitate a critical patient. Prior to simulation, the heart rates of the 34 medical students were between 62 and 78 BPM, while during the simulation they hiked to between 137 and 151 BPM, which was quite concerning. This work contains a missing important activity i.e. measuring heart rates after simulation, which is imperious to observe how quick the participants recovered from stress. Another gap is that they did not include stress mitigation activity, such as debriefing.

In summary, the current literature review shows that heart-rate based stress detection has been a standard of practice to identify the level of stress among students, however the stress mitigation and/or prevention methods have not been comprehensively explored, specifically in lecture delivery methods. Thus, this proposal aims to fill up this research gap.

3. Significance of Research

3.1 Mental Health Awareness

The outcome of this research could be used by teachers/lecturers nationwide or even worldwide to arrange their lectures so that they maintain students' mental health and eventually maximize students' cognitive performance.

3.2 Revenues And Reputation of Universities

The optimal lecture delivery method can be promoted by higher educational institutions and the Ministry of Educations in order to prevent or minimize level of stress among students. This may change the stigma that University life is stressful. By nurturing students' mental health, Universities may have more positive image, which could result in higher enrollment rate of new students. And this would eventually increase Universities' revenues.

3.3 STEM Workforce

Comfortable lecture delivery method in STEM subjects may improve enrolment rate in STEM-dominated courses, and this may gradually increase the number of STEM-based graduates and solve the shortage of STEM workforce in Malaysia in the future.

4. Methodology

The experiments will fill up the gaps in the existing students' stress management and prevention methods. They will implement different varieties of lecture delivery methods that revolve around the number of breaks, group size, room size, and seating arrangements. See Figure 1 below for the proposed experiments' framework.

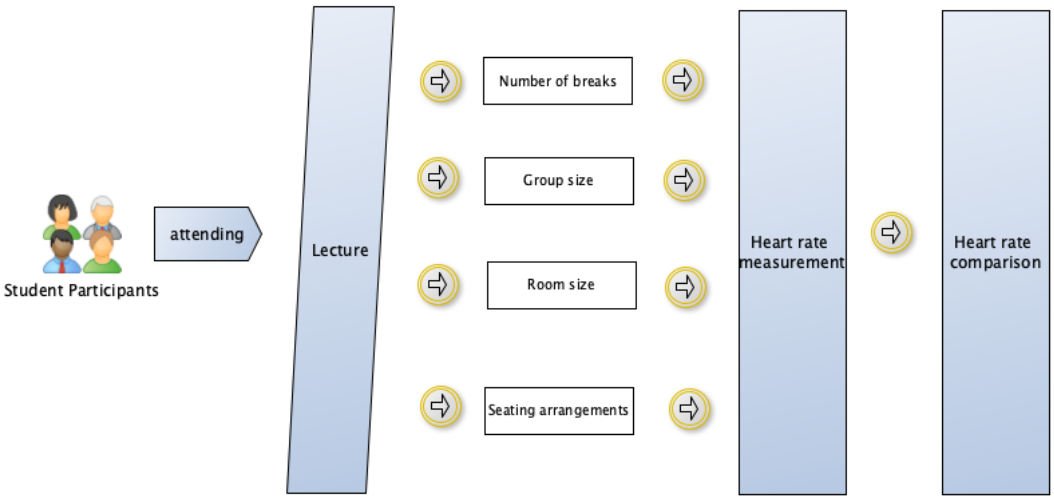

Fig. 1. Framework outlining the experiments of different lecture delivery methods

The experimented lecture delivery methods will be evaluated based on the recorded students' heart rates. The students would wear wrist-worn smart watch that detects and records heart rate. Heart rate below 100 BPM would be accepted as clinically healthy, but the otherwise would signal a stress condition. Based on the previous related work [10], we hypothesize that even a cognitively active student would have heart rate below 85 BPM – meaning that the stress condition (above 100 BPM) needs to be seriously mitigated since it contains significant jump. The generated heart rate dataset would be statistically analyzed with essential statistical conclusions, such as maximum value, minimum value, and average value.

5. Results

5.1 Experiments Set-Ups

The experimented lecture delivery methods were comprised of overall nineteen (19) classes of the following technical Information Technology (IT) subjects (STEM-related):

i. Subject Code: MTN3023, Subject Name: Computer Networks
ii. Subject Code: MTN3024, Subject Name: Network Security
iii. Subject Code: MKN2013, Subject Name: Internet of Things (IoT)

The respective classes were conducted with alternate seating arrangements (close or far seating), break inclusion or exclusion. And due to the time constraint and the amount of materials needed to be delivered, the number of break inclusion was limited to only one (1), otherwise there would not be ample time to deliver the lecture materials. Furthermore, there was also room constraint, where only one type of lecture room was available for all classes; the small room with about 4 metres of radius distance between lecturer and students.

The students' heart rates (both males and females) would be continuously measured during every class by a smart watch worn by each student. The smart watch model is of a reputable brand and one of the latest models available in the market; Huawei Band 6.

5.2 Statistical Findings

For brevity, the complete heart rate dataset for every class is not presented in this paper, instead it will present the statistical summary and discussion. However, it is worth mentioning that in general, our dataset shows that almost all peak heart rates from each student to be above 100 BPM. This is

significantly higher than the one found by [10], where all students in active learning mode had peak heart rates below 85 BPM. It may imply that STEM and/or IT subjects in general is highly challenging regardless of lecture delivery methods used, hence the highly elevated active learning state that was indicated by consistently high heart rates (above 100 BPM).

Since the recorded peak heart rates are mostly above 100 BPM, thus in order to look for outliers or the most stressed out students, this research increases the threshold for high heart rate indication from 85 BPM to 120 BPM. In other words, students with 120 BPM of peak heart rates would be considered in stressed state and the respective lecture delivery method would be analyzed. The following table compiles the numbers of recorded peak heart rates above 120 BPM from every experimented class.

Table 1 depicts that the most number of students that reached peak heart rates above 120 BPM in a class is six (6) with the number of students or participants between 14 to 16 students. In the particular case for MTN3023 GROUP E 20/12/2022 with far seating arrangement (2-chair distance) and break included, it even had a student whose lowest heart rate was very high at 85 BPM. This infers that the student was unable to reach resting heart rate which is normally below 70 BPM. Other classes with similar case include the following:

- MTN3023 GROUP D 9/1/2023 with 80 BPM of lowest heart rate, close seating (students next to each other), and without break
- MTN3023 GROUP E 27/12/2022 with 76 and 77 BPMs of lowest heart rates, close seating, and without break
- MTN3023 GROUP E 3/1/2023 with 80, 81, and 85 BPMs of lowest heart rates, close seating, and with break
- MKN2013 GROUP A 9/1/2023 with 78 BPM of lowest heart rate, close seating, and without break
- MTN3023 GROUP D 29/12/2022 with 72 BPM of lowest heart rate, far seating, and with break

The previously mentioned classes are highlighted in Table 1 in italic and bold texts. Most of them had high number of students with peak heart rates above 120 BPM (between 4-6 students), hence this may imply that for topics which were considered more challenging for most students, they might induce even higher stress level for some students.

Table 1
The numbers of peak heart rates above 120 BPM

Class Code	No. of Participants	Seating Arrangement	Inclusion of Break	Average Lowest Heart Rate	Average Peak Heart Rate	No. of Peak Heart Rate above 120 BPM	Topic
MTN3023 GROUP E 20/12/2022	***15***	***Far (2-chair distance)***	***Yes***	***64***	***115.86***	***6***	***Routing protocol simulation using Cisco Packet Tracer - OSPF***
MTN3023 GROUP D 5/1/2023	14	Close	Yes	63.71	119.07	6	Discussion of network layer exercises
MTN3023 GROUP D 9/1/2023	***16***	***Close***	***No***	***67.13***	***118.06***	***6***	***Data link layer simulation with extensive troubleshooting***
MTN3023 GROUP E 13/12/2022	13	Close	No	62.46	116.23	5	Simulation using Cisco Packet Tracer

MTN3024 GROUP A 13/1/2023	15	Close	No	63.2	118.27	5	Azure Cloud Storage - Connect an App Securely with extensive troubleshooting
MTN3024 GROUP A 16/12/2022	16	Close	No	63.5	110.37	4	Cryptography - Affine and Vigener algorithms exercises
MTN3024 GROUP A 23/12/2022	16	Close	No	61	110.94	4	Hashing exercises with extensive problem solving - Linear & quadratic probes
MTN3023 GROUP E 27/12/2022	***15***	***Close***	***No***	***67.53***	***118.06***	***4***	***Routing protocol simulation using Cisco Packet Tracer - OSPF (modified simpler case study from last week)***
MTN3023 GROUP E 3/1/2023	***16***	***Close***	***Yes***	***66.31***	***118.5***	***4***	***Discussion of Network Layer Exercises Part III***
MKN2013 GROUP A 9/1/2023	***15***	***Close***	***No***	***64***	***116.93***	***4***	***Azure Cloud Storage Creation***
MTN3023 GROUP E 10/1/2023	15	Close	No	61.2	114.47	4	Switch VLAN simulation with extensive troubleshooting
MKN2013 GROUP A 16/1/2023	14	Close	No	63.93	114.71	4	Group exercise of 4 or 5 people per team about Smart-Wearable project solution
MKN2013 GROUP A 12/12/2022	14	Close	No	62.79	113.71	3	Myduino hardware programming
MTN3023 GROUP D 12/12/2022	15	Close	No	63.6	111.73	3	Simulation using Cisco Packet Tracer
MTN3023 GROUP D 19/12/2022	15	Close	No	64.2	112.46	3	RIP simulation using Cisco Packet Tracer with extensive troubleshooting
MTN3024 GROUP A 30/12/2022	17	Close	Yes	64.59	115.18	3	Hashing exercises with extensive problem solving - Hill Cipher and also encryption using python
MKN2013 GROUP A 19/12/2022	14	Close	No	62.64	110.71	2	Serial communication simulation exercises on Tinkercad
MTN3023 GROUP D 29/12/2022	***8***	***Far (2-chair, 4-chair, 10-chair distances)***	***Yes***	***63.37***	***112.62***	***1***	***Simulation using Cisco Packet Tracer - OSPF protocol (modified simpler case study from last week)***
MTN3024 GROUP A 6/1/2023	14	Close	No	60.29	112.79	1	Apache server hardening with extensive problem solving

The outcome of MTN3023 GROUP E 20/12/2022 infers that far seating arrangement may potentially cause higher stress level for some students, which is shown by the lowest recorded heart rate (a.k.a. resting heart rate), which was significantly high at 85 BPM.

Those highlighted classes also show that the inclusion or exclusion of break did not make obvious difference to the generated heart rates. This could be due to the nature of activities in classes, where students could take "unofficial" break during class exercises or labs. Therefore, taking break during class is essential to destress students - either it is done by official break instructed by the lecturer - or by unofficial break taken while students are doing a task or class exercise. The effectiveness of inclusion of break to reduce heart rate is shown by MTN3024 GROUP A 30/12/2022 and MTN3023 GROUP D 29/12/2022 classes, where the numbers of students with peak heart rate above 120 BPM are very few; three (3) students and one (1) student respectively.

There is a noticeable pattern for the classes with lowest average peak heart rates, namely MTN3023 GROUP D 12/12/2022, MTN3024 GROUP A 23/12/2022, MKN2013 GROUP A 19/12/2022, MTN3024 GROUP A 16/12/2022 , each of these delivered lighter topic compared to the rest. Based on this, we may conclude that lighter topics are more consequential to less stress for students compared to seating arrangement and/or inclusion of break.

In our full dataset, consistently in all experiments, there is no heart rate pattern, which may propose that either male or female gender is more vulnerable to stress than the other. This could be a sign that STEM subjects have equal effect on both male and female students.

6. Conclusions

The currently completed experiments conclude that optimal lecture delivery method contributes to the level of stress among students with inclusion of break being the most crucial factor to reduce stress among students. Furthermore, the topic's level of difficulty of the STEM subjects has also been observed as the most impactful contributing factor to students' level of stress. In addition, it was also found that a class with far seating arrangement may contain a latent stress for specific students shown by their high level of resting heart rate, which infers instant and persistent stress induction. However, more experiments could be done to continue investigating possible optimal lecture delivery method.

Moreover, deeper understanding of students' learning ability could be assessed in the future along with lecture delivery method. An example of learning ability assessment was done related to Spatial Visual Intelligence [14], where students were assessed regarding their responses to understand and utilize writing and/or pictorial symbols. This is especially related to this paper's research since all the covered subjects include network simulation that uses programming syntaxes (writing) and hardware icons (pictorial symbols). Gamification may also be implemented to improve students' mood as the one done by paper [15]. While a full-fledged smart system may also be developed and utilized to monitor and manage the behaviour of students as experimented by researchers in paper [16] along with analyzing their social media activities – in order to detect their growing interest in STEM subjects [17]. From additional perspective, stress levels of STEM-enrolled students may also be affected by the psychological condition and/or stress level of the corresponding lecturer [18], hence this factor may be taken into account in the future experiments.

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