

A STUDY ON THE FACTORS AFFECTING THE PERFORMANCE OF NAUTICAL STUDENTS DURING FULL MISSION SHIP BRIDGE SIMULATION TRAINING

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ABSTRACT

This study examines the contributing factors to nautical students' performance in Full Mission Ship Bridge Simulator Training (FMSBST). Based on the Analytic Hierarchy Process (AHP), the study determines and prioritises contributing factors: Instructor quality, training content, facilities, and personal factors. Questionnaires were distributed among 20 nautical students and six instructors from Universiti Malaysia Terengganu (UMT), Universiti Pertahanan Nasional Malaysia (UPNM), and Sealestial Marine Seafarer's Training Centre (SEAMASTER). The results revealed that instructors are the most significant factor (32.24%), followed by training content (25.44%), facilities (22.64%), and personal factors (19.68%). The findings also present practical recommendations to improve simulator training, including enhancing instructor expertise, revising training materials, and upgrading simulator facilities. This study contributes to maritime education by presenting evidence-based solutions to maximise student performance in FMSBST.

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Introduction

Background of Study

Simulator training has become an essential requirement for all seafarers in the shipping industry, providing bridge officers with realistic training experiences that replicate real-world marine operations. Full-mission ship bridge simulators offer comprehensive virtual environments that accurately simulate bridge controls, instruments, and displays, allowing trainees to practice navigation, collision avoidance, and emergency response procedures in safe yet challenging conditions (Chiurco *et al.*, 2015).

As a multifaceted training tool, simulation enables the replication, duplication, and projection of reality through various methods ranging from role-play to advanced computer-based models (Zghyer & Ostnes, 2019). These technologies have proven particularly valuable

in high-stakes industries like maritime and aviation, where they minimise operational errors, enhance hazard recognition, and mitigate risks through near-realistic training scenarios.

Research Problem

Despite the widespread adoption of simulator training in maritime education, significant variability persists in student performance outcomes. Research has largely focused on technical aspects of simulation while neglecting how simulated contexts are collaboratively constructed during training sessions (Hontvedt & Arnseth, 2013). This gap in understanding is critical, as the effectiveness of the training with the simulators depends on the complex interplay between instructional methods, environmental factors, and individual learner characteristics

and not just on technical fidelity. Currently, there is insufficient research identifying which factors significantly impact nautical students' performance in FMSBST, or how these elements interact within the training context.

Scope of the Study

To address the research gap, the study focuses on maritime students from Universiti Malaysia Terengganu (UMT), Universiti Pertahanan Nasional Malaysia (UPNM), and Sealestial Marine Seafarer's Training

Centre (SEAMASTER) who have undergone FMSBST. By systematically investigating key performance factors including instructor expertise, training content quality, simulator fidelity, and individual learner characteristics, this research aims to provide actionable recommendations for optimising maritime training programmes. The findings aims to contribute to both the theoretical understanding and practical improvement of simulator training, which will ultimately enhance the preparation of future maritime professionals for the complex challenges that they will face at sea.



Figure 1: Full Mission Ship Bridge Simulator Training (FMSBST) at UMT

Literature Review

Key Concept of Full Mission Ship Bridge Simulator

The full-mission ship bridge simulator at Universiti Malaysia Terengganu (UMT) is one of the facilities that nautical students can use for learning and training before sailing on board a vessel (Figure 1). Navigators and officers receive realistic and practical instruction via a comprehensive and immersive FMSBST programme (Chiarco *et al.*, 2015). The programme involves the use of advanced ship simulators that recreate the bridge environment and numerous maritime scenarios, allowing

trainees to practice navigation and emergency response procedures in a risk-free environment, contributing to improved safety awareness and preparedness.

The simulators recreates a number of scenarios, such as harbour manoeuvres, open-water navigation, and emergency situations by simulating various weather conditions, sea states, and marine habitats (Last *et al.*, 2017). This realism allows trainees to confront and respond to genuine obstacles that they may encounter at

sea. Simulators provide students with a secure and controlled environment, as well as a cost-effective alternative to traditional onboard training, reducing the expense associated with fuel, maintenance, and mitigating the potential risks associated with live exercises at sea (Last *et al.*, 2017).

Trainees can make mistakes, learn from them, and try new techniques without risking their lives, causing environmental damage, or damaging actual seagoing vessels. This builds a learning environment that encourages exploration as well as the development of competence and confidence. FMSBST has become an essential component of maritime education and training programmes all around the world (Chirco *et al.*, 2015). It provides a secure, realistic, and effective platform for developing ship navigation skills, decision making, and encouraging teamwork and communication among bridge crew members. Simulator training leads to safer and more efficient ship operations by preparing trainees for various maritime scenarios, eventually boosting maritime safety and professionalism.

Nautical Students’ Performance

The performance of naval students as trainees during ship bridge simulator training was evaluated using several elements, such

as their knowledge, abilities, and general competence in marine operations. There are numerous factors that influence students’ performance: Personal, training content, instructor, and facilities. It is crucial to highlight that evaluating the performance of nautical students is a complete process that considers both academic achievements and practical skills. Evaluations may incorporate written examinations, practical assessments, simulations, onboard evaluations, and input from industry professionals. The goal is to prepare students to face the challenges and responsibilities of a maritime-based career.

Enhancing nautical students’ performance in FMSBST is critical for preparing competent maritime professionals. As instructor-led simulator training forms the foundation of real-world operational skills, optimising student outcomes directly contributes to safer and more efficient shipping practices. Beyond technical proficiency, fostering intrinsic motivation, particularly by cultivating passion for maritime operations that can significantly improve engagement and performance. When students develop a genuine enthusiasm for the field, they are more likely to approach simulator sessions with diligence, which would ultimately translate to better decision-making and crisis management abilities onboard actual vessels.

Table 1: List of factors that influenced nautical students’ performance

No.	Main Criteria	Sub-criteria
1	Personal (SCA) Personal life, referring mainly to self-transcendent values, was the prominent motive underlying sources of meaning (Fave <i>et al.</i> , 2013)	<ul style="list-style-type: none"> • Health Factor (SCA 1) (Baharin <i>et al.</i>, 2015; Sael <i>et al.</i>, 2019) • Time Management (SCA 2) (Baharin <i>et al.</i>, 2015) • Previous Semester Achievement (SCA 3) (Sael <i>et al.</i>, 2019; Tasrif <i>et al.</i>, 2021)
2	Training Contents (SCB) The official training content definition includes any and all information presented to learners with the aim of teaching knowledge or skills (Andriotis & Andriotis, 2017)	<ul style="list-style-type: none"> • Quality of Education (SCB 1) (Sael <i>et al.</i>, 2019; Tasrif <i>et al.</i>, 2021) • Learning Material Preparation (SCB 2) (Saaludin <i>et al.</i>, 2019) • Training Syllabus Arrangement (SCB 3) (Sael <i>et al.</i>, 2019)

<p>3 Facilities (SCC) A training facility for adult professionals must have flexible and technologically-advanced learning environments that are safe, healthy, comfortable, aesthetically-pleasing, and accessible (Training Facility WBDG - Whole Building Design Guide, 2017)</p>	<ul style="list-style-type: none"> • Infrastructure Completeness (SCC 1) (Baharin <i>et al.</i>, 2015) • Comfort of Training Room (SCC 2) (Baharin <i>et al.</i>, 2015) • Friendly User of Training Device (SCC 3) (Baharin <i>et al.</i>, 2015) • Arrangement of Training Device (SCC 4) (Baharin <i>et al.</i>, 2015)
<p>4 Instructor (SCD) Instructors are important and are responsible to connect the simulator experience with real ship experiences through their visualisation and not let the trainee get into a discourse or fall into a game mood (Ali, 2006)</p>	<ul style="list-style-type: none"> • Knowledge (SCD 1) (Baharin <i>et al.</i>, 2015) • Instructors' Interaction & Guidance (SCD 2) (Saaludin <i>et al.</i>, 2019; Sael <i>et al.</i>, 2019) • Instructor Experience (SCD 3) (Baharin <i>et al.</i>, 2015; Sael <i>et al.</i>, 2019) • Teaching Aids Readiness (SCD 4) (Mohammed & Daham, 2021)

Table 1 outlines four key factors that influence nautical students' performance in FMSBST. First, personal factors such as health, time management skills, and previous academic performance form the foundation for learning success. Second, the quality of training content, including educational materials and syllabus organisation, directly impacts knowledge acquisition. Third, facility considerations like equipment availability, classroom comfort, and user-friendly simulator interfaces create the physical learning environment. Finally,

instructor qualifications encompassing subject knowledge, teaching experience, interaction skills, and preparation of teaching aids are crucial for effective knowledge transfer.

Together, these interrelated elements which are personal readiness, curriculum quality, training facilities, and instructor competence that collectively determine students' ability to develop essential maritime skills through simulator training, with each component supported by recent academic research in the field.

Methodology

Research Framework

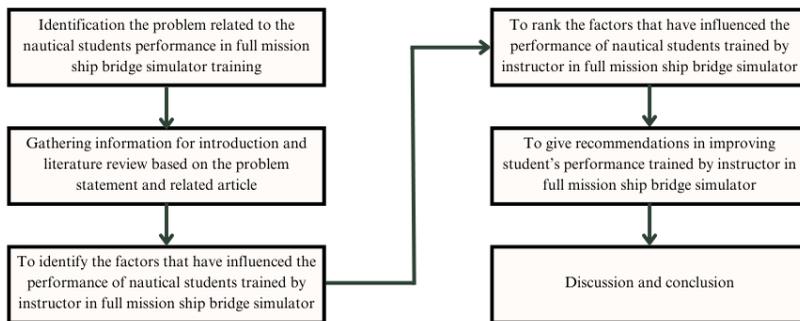


Figure 2: Research flow

Data Collection Strategy

Data collection, which involves empirical research or data analysis is an essential part of this study. Researchers gather, measure, and

analyse precise data from various pertinent sources to address research issues, evaluate results, and predict trends and probabilities

(Simplilearn, 2023). This study achieved its first objective via a literature review. The aim of the literature review was to identify the factors that influenced the performance of students at the naval academy trained by instructors in a full-mission ship bridge simulator (Figure 3). The study conducts a thorough search and analysis of published literature, peer-reviewed journal articles and other frequently reviewed relevant sources.

In order to address the second research objective, the study made use of the Analytic Hierarchy Process (AHP) to systematically rank the key factors influencing maritime students' performance during instructor-supervised training on full-mission ship bridge simulator that replicate actual navigation environments. Then, employed a literature review and student feedback interviews to achieve the third objective, which is to provide suggestions for enhancing the students' performance in the instructor-led full-mission ship bridge simulator training.

Sampling Strategy

This study included 20 nautical students from different levels (first to fourth year) and six experienced instructors from UMT, UPNM, and SEAMASTER. All the participants had completed at least one full ship bridge simulator training session, giving them hands-on experience with the equipment. Meanwhile, all the instructors had at least three

years of teaching experience. By including students at different stages of training, the research examined how experience affected simulator performance, but the study focused specifically on what factors influenced student performance during simulator training. This mix of participants provided both beginner and advanced perspectives while keeping the study focused and practical.

Types of Analysis Method Applied

The data collected during the study was analysed using an AHP method to identify and rank the factors and suggest recommendations to improve the student's performance. The AHP is one of the most inclusive systems, for decision-making purposes as it allows the use of several criteria and allows researchers to formulate the problem as a hierarchy and make use of a mixture of quantitative and qualitative measures as well (Taherdoost, 2020). Table 2 shows scale technique used to record the judgements from the participant of this survey.

Step 1: Identify the factors that have influenced the performance of nautical students trained by instructors in full mission ship bridge simulator that shown in Table 1.

Step 2: Prepare and distribute a Google Forms questionnaire to students and maritime experts at the naval academy to rank the factors affecting trainee performance in comprehensive ship bridge simulator exercises conducted under instructor supervision.

Table 2: Scale technique used to record the judgements from the participant of this survey

Saaty Scale	Definition of Scale (Linguistic Term)	Description
1	Equally affect	Both criteria equally affected student performance
3	Weekly affect	Criteria weakly affected student performance
5	Fairly affect	Criteria fairly affected student performance
7	Strongly affect	Criteria strongly affected student performance
9	Absolutely affect	Criteria absolutely affected student performance
2, 4, 6, 8	The intermittent values between two adjacent scales	Criteria had an intermittent effect on the adjacent scales that affect student performance

Step 3: Analyse the data. For the purposes of this research article the data analysis involved the following steps. First a pairwise comparison Matrix A is extracted from the data collected in the questionnaire. The principal eigenvector of

Matrix A is computed as ‘w’. A weight value assessment is arranged in the form of matrix. The attributes of a_i and a_j and are denoted as follows (Abdul Rahman, 2012):

$$A = (a_{ij}) = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a/a_{12} & 1 & \dots & a_{2n} \\ \cdot & \cdot & \dots & \cdot \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \tag{1}$$

where, the item denoted as $i, j = 1, 2, 3, \dots, n$ and each a_{ij} is respect of attribute a_i to attribute a_j .

Step 4: The weight values of the main criteria and sub criteria was obtained using manual

calculation as stated in Equation 2 (Abdul Rahman, 2012; Asuquo *et al.*, 2014):

$$w_k = \frac{1}{n} \sum_{j=1}^n \left(\frac{a_{kj}}{\sum_{i=1}^n a_{ij}} \right) \tag{2}$$

Step 5: To reach a convergence between the answers to successive repetitions of this process, calculations should be repeated several times in order to decide especially when faced with

an incompatible matrix. Then, the following formula is applied to transform the raw data into meaningful absolute values and normalise the weightage $w = (w_1, w_2, w_3 \dots w_n)$ (Taherdoost, 2020):

$$\lambda_{max} = \frac{\sum_{j=1}^n \frac{\sum_{k=1}^n w_k a_{jk}}{w_j}}{n} \tag{3}$$

Step 6: In order to validate the results of the AHP, the Consistency Ratio (CR) is calculated

using the formula, $CR = CI/RI$ in which the Consistency Index (CI) is measured through the following formula (Taherdoost, 2020):

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{4}$$

($n = 1, 2, 3, n$, matrix size)

Step 7: It should be noted that CR lower than 0.10 verifies the results of comparison are acceptable (Taherdoost, 2020). While RI is the

random index for the matrix size. The value of RI depends on the number of items being compared as given in Table 3 (Saaty, 2008):

$$CR = \frac{CI}{RI} \tag{5}$$

Table 3: Random consistency index from 1 to 10 of matrix size

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (2008)

The ultimate ranking and decisions are made at the end. The primary characteristic that influenced a students’ performance in instructor-led mission ship bridge simulator training was identified.

Recommendation

In this phase, the research findings were evaluated by experts to assess their validity

and practical applicability. Following this review, evidence-based recommendations were derived from expert analysis to enhance a maritime academy students’ performance in comprehensive ship bridge simulator training programmes. These strategies aim to optimise instructional methods, simulator use, and learning outcomes within a structured maritime training framework.

Results and discussion

Each of the main factors and sub-criteria was ranked based on a Normalised Principal Eigenvector value (Figure 3). The Normalised Principal Eigenvector could be converted to

a percentage. The weight of the Normalised Principal Eigenvector reflects the rank of the criteria, the higher the value, the higher the priority and rank of the criteria.

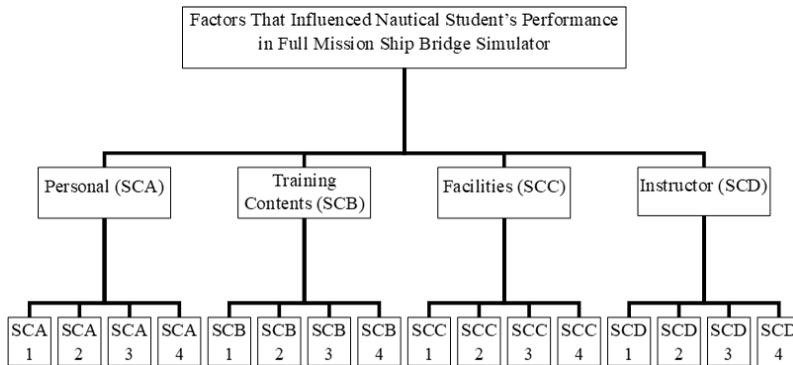


Figure 3: Summarisation of main criteria and sub-criteria that influenced students’ performance

Key Findings from the Survey of Nautical Students

The key factors identified in the survey is illustrated in Figure 4. A suitable Random Consistency Ratio (RI) value was obtained from Table 3; RI = 0.9 if n = 4. CR = 0.0006 or 0.06%, CI = 0.0005, Principal Eigenvalue, λ_{max} = 4.0015.

Table 4, set all of the factors that influence student performance in full mission ship bridge

simulators in an orderly manner. The results showed that the most significant factor that affected student performance was the instructor (0.3224), this was followed by training content (0.2544), facilities (0.2264), and finally personal factors (0.1968). A CR of 0.0006, confirmed that the results of the survey were consistent and reliable.

Key Findings from the Survey of Nautical Students

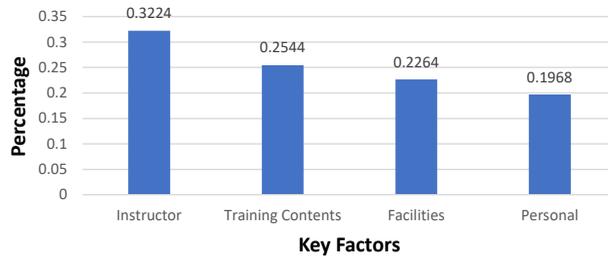


Figure 4: Statistical graph of main factors

Table 4: The percentage values of the normalised principal eigenvector

Main Factor	Normalised Principal Eigenvector	Principal Eigenvector in Percentage Values	Rank
Instructor	0.3224	32.24%	1
Training Contents	0.2544	25.44%	2
Facilities	0.2264	22.64%	3
Personal	0.1968	19.68%	4

Key Findings from the Survey of Experts

The main factors from the experts’ survey is shown in Figure 5. The suitable value of the Random Consistency Ratio RI is obtained from Table 3; RI = 0.9 if n = 4. Consistency Ratio = 0.0033 or 0.33%, CI = 0.0029, Principal Eigenvalue, $\lambda_{max} = 4.0088$.

The results outlined in Table 5, set out the factors that most influenced student performance

in full mission ship bridge simulator sessions with the instructor (0.3001) being the most influential factor, followed by training content (0.2666), while the facilities ranked third (0.2189), and with personal closing out the rankings (0.2145). The CR open data collected was 0.0033 which confirmed that the results of the survey were consistent and reliable.

Key Findings from the Survey of Experts

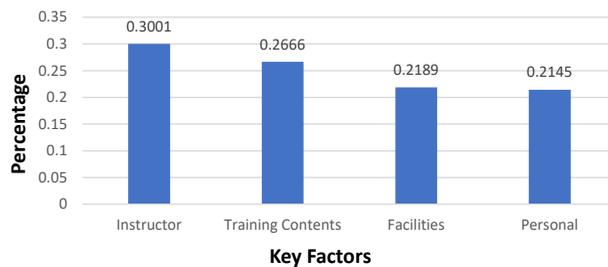


Figure 5: Statistical graph of main factors

Table 5: The percentage values of the normalised principal eigenvector

Main Factor	Normalised Principal Eigenvector	Principal Eigenvector in Percentage Values	Rank
Instructor	0.3001	30.01%	1
Training Contents	0.2666	26.66%	2
Facilities	0.2189	21.89%	3
Personal	0.2145	21.45%	4

As referred in Table 4, the main criteria—the instructor (0.3224) was ranked as first and most important of the factors obtained based on the data collected in the survey given to the students at the maritime academy, with reference to Table 5, the criteria of instructor (0.3001) was also ranked as the first most important of the factors in the survey given to the experts. Instructors play a very important role in simulator training programmes that have significant impact on and can heavily influence a students’ performance during practical sessions. The training content criterion (0.2544) and (0.2666) holds second place.

In general, training content plays a crucial role in facilitating structured learning and making it easier to understand the learning outcomes of each session.

Facilities ranked at 0.2264 and 0.2189 is the third most important criteria. Great facilities can also contribute to the effectiveness of the learning processes and the achievement of the learning outcomes, as better technologies can provide a wider array of real-life situations onboard a ship. The primary criteria of personal health (0.1968) and (0.2145) ranked fourth. These findings are well supported by the systematic review by Abida and Suhrabb (2024), who emphasised the importance of instructor competence and effective debriefing in enhancing simulation-based learning. Their study also highlighted those realistic and structured training scenarios, closely aligned with regulatory requirements, significantly improved trainee performance, and validating the importance of well-designed training content.

In addition, Abida and Suhrabb (2024) found that high-fidelity simulator environments

positively affect learning by improving realism and immersion. Finally, the study addressed trainee motivation and prior experience as important contributors to simulation effectiveness, aligning with the influence of personal factors in this study.

Recommendations

Based on the interview session with the respondents, who are nautical students and instructors, the study can summarise the recommendation as follows:

Improving trainee performance in ship bridge simulator training is a critical aspect of ensuring safety and efficiency of maritime operations. A descriptive analysis of the factors influencing trainee performance revealed that instructors, training contents, facilities, and personal factors all play a crucial role in shaping the learning outcomes. Instructor-led training is a vital component of ship bridge simulator training, and effective instructors can make a significant difference in trainee performance. Experts in ship navigation, operations, and emergency procedures can offer trainees personalised guidance and feedback.

Moreover, instructors who possess excellent communication skills can facilitate a more engaging and interactive learning environment, which is essential for optimal learning outcomes. For instance, an instructor who is able to explain complex concepts in a clear and concise manner can help trainees better understand the material and apply it to real-world scenarios. Additionally, instructors who are able to provide constructive feedback and encouragement can help build trainee confidence and motivation, which is essential for overcoming the challenges of ship bridge simulator training.

The training content itself is also critical to improve trainee performance. A comprehensive training program that covers all aspects of ship operations, including normal, abnormal, and emergency situations is essential for providing trainees with the knowledge and skills they need to succeed. Scenario-based training, in particular has shown to be an effective way to simulate real-world situations and challenge trainees to develop decision-making skills and crisis management strategies. Furthermore, regular updates to the training contents ensure that trainees are familiar with the latest regulations, technologies, and industry best practices, which is essential for staying relevant in the rapidly evolving maritime industry.

The facilities themselves are also a critical component of ship bridge simulator training. State-of-the-art equipment that is well-maintained and reliable is essential for providing a realistic and engaging learning environment. Moreover, trainees can develop their skills in a more realistic and immersive way with facilities designed to simulate real-world bridge conditions, including weather and sea conditions. Additionally, comfortable seating and adequate space for trainees to move around comfortably, help reduce fatigue and distractions, which is essential for optimal learning outcomes.

Finally, personal factors such as motivation, self-directed learning, and feedback seeking; also play a critical role in improving trainee performance. Trainees who are motivated to learn and set personal goals for themselves are more likely to stay engaged and focused during training. Moreover, self-directed learning activities such as review and practice can help trainees reinforce their learning and build confidence. Furthermore, feedback-seeking behaviours of asking questions and seeking feedback from instructors can help trainees identify areas for improvement and develop their skills further.

Conclusion and Implications

This study successfully achieved its objectives by examining the key factors influencing nautical students' performance in Full Mission Ship Bridge Simulator Training under instructor supervision. Through a thorough review of relevant literature, four primary factors were identified and analysed: Instructor quality, training content, facilities, and personal factors. The AHP was then applied to systematically rank these factors, revealing that instructor expertise held the greatest influence at 32.24%, followed by training content at 25.44%, facilities at 22.64%, and personal factors at 19.68%.

The formulation of practical recommendations was based on these findings, focusing on actionable strategies to enhance training effectiveness. These recommendations include increasing the frequency of training sessions to reinforce skills, incorporating realistic scenarios to improve decision-making abilities, adapting teaching methods to better suit different learning styles, and optimising the physical training environment to maximise engagement. By implementing these measures, the study aims to elevate the overall quality of simulator training programmes, ultimately leading to better-prepared maritime professionals. This research not only contributes to academic knowledge regarding performance factors in simulator training but also provides concrete guidance for improving instructional approaches and training outcomes in maritime officer education.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

Author Contributions Statement

The corresponding author, Muhammad Nasir Rahmatdin performed validation and verification of results and produced the results. The second author Alina Pannirselvam contributes to literature review and data collection. All authors contributed to the writing, review, and final approval of the manuscript.

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