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ERGONOMICS RISK FACTORS (ERF)s THAT INFLUENCED TOWARDS COGNITIVE ERGONOMICS AIMED FOR WORK PERFORMANCE AT ONSHORE FABRICATION PROJECTS OIL AND GAS INDUSTRY IN MALAYSIA

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Abstract: *The relationship between physical, cognitive, and organizational ergonomics for the 21st century is essential for working environments. Physical ergonomics contributes to the organizational ergonomics, as well as being responsible for the cognitive ergonomics that require the supportive workplace for the ergonomic balance in the working environment. Cognitive ergonomics is the visual of mental work environment and tasks so that people are healthier, more comfortable, and more productive while lowering the risk of mental illness or stress. While the management of physical ergonomics is well-established, cognitive ergonomics also takes it into account and positively influences organizational ergonomics. Qualitative methods gather factors that influence cognitive ergonomics in organizational environments. The focus group interviews experts who work on the construction sites of onshore fabrication projects in the oil and gas industry. ARC techniques and deductive methods in Qualitative Methodology are used to look at the results and analyze cognitive-related physical and organizational factors that affect the environment. Therefore, systematic task delivery, two-way communication, and clear knowledge transfer significantly influence cognitive ergonomics. Hence, the factors that influence cognitive ergonomics are both physical ergonomics and organizational ergonomics, which are essential aspects of creating a balanced and effective working environment in the thematic for Design Improvement, Workload Management and Work Environment Control. Each of these thematic and constructs plays a crucial role in ensuring the well-being, productivity, and overall success of employees within an organization. Future research might conduct through Quantitative Methodology.*

Keywords: *Ergonomics Risk Factors, Cognitive Ergonomics, Work Performance, Onshore Fabrication project, Oil and Gas Industry*

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Introduction Relationship Between Cognitive Ergonomics and Work Performance

Ergonomics is the scientific discipline focused on the design and arrangement of workplaces, products, and systems to accommodate their users. It aims to enhance human well-being and total system efficacy by aligning tasks, tools, and surroundings with human capabilities, constraints, and requirements. Essential elements of ergonomics encompass the Physical Ergonomics concerns human anatomy and physical activity, including workstation configuration, posture, and the prevention of repetitive strain injuries. Second, cognitive ergonomics in pertaining to mental processes, including perception, memory, and decision-making, within human-system interaction. Third, Organizational Ergonomics shall concentrate on enhancing sociotechnical systems, including communication, collaboration, and work scheduling. The objective of ergonomics is to alleviate discomfort, avert injuries, and enhance efficiency and production (Korhan et al., 2022). Researchers in the field of ergonomics have increasingly focused on the impact of cognitive ergonomics within the oil and gas industry, particularly in onshore fabrication projects (Kurzhunbaeva et al., 2024). Cognitive ergonomics play a crucial role in improving safety and productivity in these environments by reducing the mental workload and enhancing decision-making processes (Sgarbossa et al., 2020). There are findings that underscore the importance of cognitive ergonomics in the dynamic and high-risk settings for construction site of onshore projects, where swift and accurate decision-making is vital (Golabchi et al., 2022).

However, contrasting opinions emerge when examining the extent to which cognitive factors are prioritized in ergonomic interventions (Metzler et al., 2019). This viewpoint is compared by Thompson et al., (2009), who contends that while cognitive aspects are important, they should be integrated with physical factors rather than viewed in isolation. Alves et al., (2019), suggests that a balanced approach could yield more comprehensive ergonomic improvements in onshore fabrication projects.

Despite the insights provided by these studies, there is a significant gap in the literature regarding the specific cognitive demands experienced by workers in onshore fabrication environments. Existing research often generalizes cognitive ergonomics across various settings, without considering the unique challenges of the onshore oil and gas industry. Moreover, there is little investigation into the interplay between cognitive and physical ergonomics, leaving a crucial aspect of worker safety and efficiency insufficiently explored. How do ergonomic risk factors influence cognitive ergonomics among workers in onshore fabrication projects within the oil and gas industry, and what impact do these factors have on safety and productivity? What are the patterns and trends in cognitive ergonomics factors affecting workers in onshore fabrication projects within the oil and gas industry? Given these gaps, it becomes apparent that there is a critical need to delve deeper into the role of cognitive ergonomics specific to onshore fabrication projects within the oil and gas industry. This research seeks to address these shortcomings by offering new insights into worker experiences and developing strategies that integrate cognitive and physical ergonomic considerations. By doing so, the study aims to contribute valuable knowledge to the field, enhancing safety and productivity for workers in this demanding sector.

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Literature Review

Onshore is described as situated or occurring on land, particularly with reference to the oil and gas business, according to a dictionary. The Client establishes a new field or enhances the structure of an existing one, referred to as a platform, for an upstream sector. The platform is constructed from the foundation, creating new fields or enhancing existing platforms or structures in the upstream sector (Olsen et al., 2005). Silvianita et al. (2017) identify the upstream structure as the jacket and topside steel structure, with the fabricator possessing their own fabrication yard. (Kurzhunbaeva et al., 2024c) mentioned safety and health of the construction sites for onshore fabrication projects in the oil and gas sector are critical as per Table 1 due to the intricate operations, utilization of heavy machinery, dangerous substances, and the risk of accidents. A strong safety culture, adherence to rules, and proactive risk management are vital for safeguarding workers and guaranteeing project success.

Table 1: Type of Hazards and Occupational Risks

Hazrad	Mitigation Measures
Heavy Equipment Movement	Spotters, traffic control, and proximity alarms.
Welding and Cuting Hazards	Use of welding shields, ventilation, and proper PPE.
Confined Space	Gas monitoring, rescue plans, and trained personnel.
Chemical Exposure	MSDS availability, spill kits, and proper storage.
Noise Level	Ear protection and noise barriers.

Source: Gaffney & Roberts, n.d.

Ergonomics Risk Factors (ERFs)

Department of Occupational Safety and Health. (2024), Ergonomic risk factors as per Guidelines on Ergonomics Risk Assessment at Workplace 2017, Department of Occupational Safety and Health, Malaysia are as follows:

i. Awkward postures is the condition that create postural stress on muscles, tendons, nerves, and blood vessels, or joints.
ii. Forceful exertions is the muscular effort to accomplish a specific movement or exertions that have significant impact on muscles, tendons, nerves, and blood vessels, or joints.
iii. Static loading which is a fixed position with muscular effort and minimum movement can easily strain muscles in short duration.
iv. Static posture, which is fixed position, with minimal movement of the particular body parts that can fatigue muscles in short duration.
v. Contact stress is localized pressure exerted against the skin by an external force that can block blood flow and damage skin tissue.
vi. Some combination, repetition or prolonged duration of ergonomics risk factors stated above
vii. Others environmental factors such as heat, vibration, etc. (if relevant)

Overview of Onshore Fabrication Projects, Oil and Gas Industry

Onshore Fabrication Projects involve the construction of a new oil platform or the refurbishment of an existing one. In the fabrication project, the contract types include Engineering, Procurement, and Construction (EPC), which is a design and construct concept. The onshore fabrication activity involves the creation of a new platform for the oil and gas industry. The structure in Upstream, Downstream, or Midstream necessitates a specific contract

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to oversee and administer the project, as seen in Figure 1. Some clients are local, like as Petronas and Shell Malaysia, while others are international, including Chevron, ONGC, and NOC.

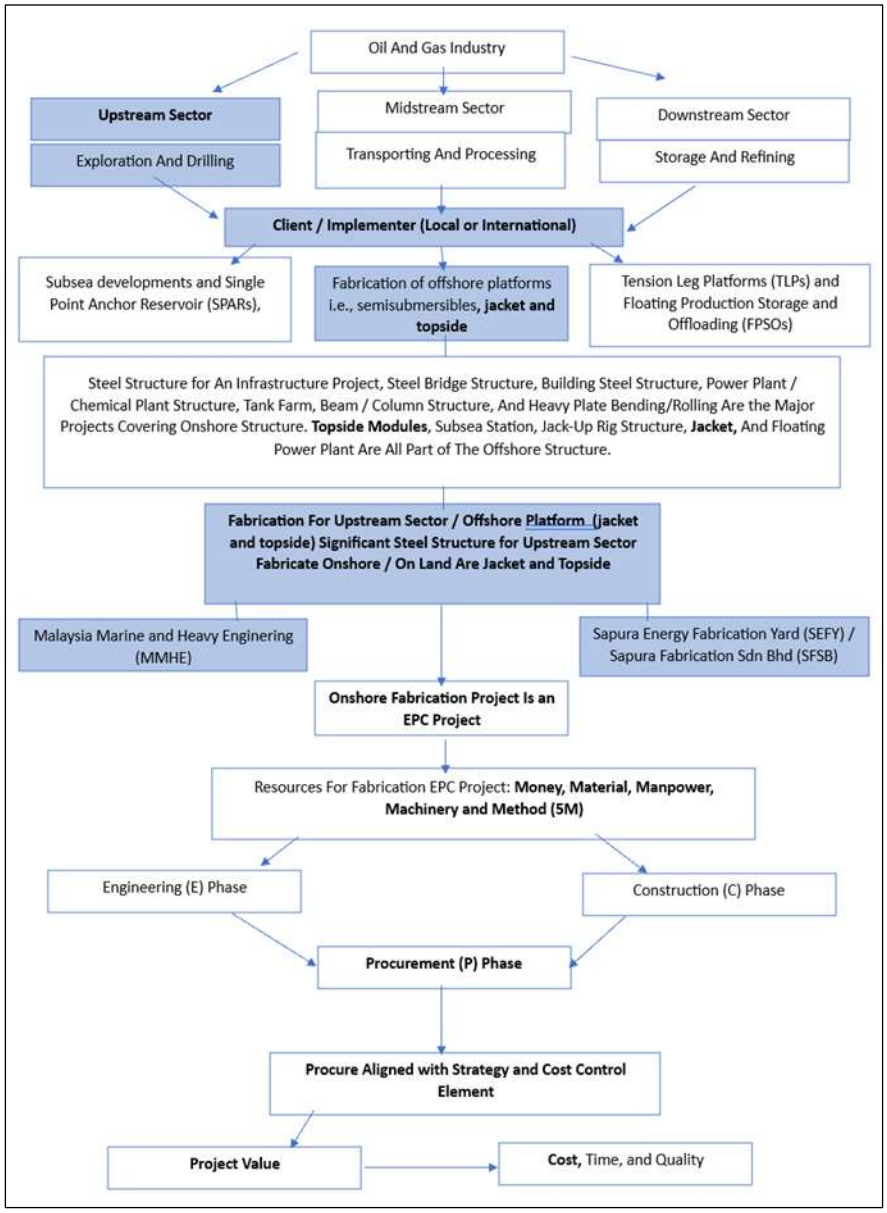

Figure 1: Overview of Onshore Fabrication project in Oil and Gas Industry
Source: Mohd Roshdi, F.R,2023

The O&G sector has shown a substantial demand for scientific, technological, and engineering competencies in the context of project management (Al Subaih, 2015). Each sector and project necessitated effective management resources to complete a project within its life cycle. The life cycle of a project delineates the resources required for each phase and the precise tasks to be accomplished at each stage. In any project, diverse combinations of manufacturing techniques, materials, and personnel can be employed to construct multiple activity execution plans (Al Subaih, 2015). Consequently, systematic project management is an adaptable procedure that fluctuates based on the project's magnitude and intricacy. Although budgeting is frequently not a decisive element in effective project management, the allocations and

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expenditures are ultimately managed (Krishnan et al., 2019). The oil and gas industry are a worldwide sector encompassing the exploration, extraction, refining, transportation, and marketing of petroleum and natural gas products. It is among the largest and most vital industries globally, serving a pivotal function in energy generation, international commerce, and industrial advancement (Devold,2013). Upstream Sector major relates to the process of exploration and extraction. Exploration is the pursuit of oil and gas deposits through geological and geophysical methodologies. Next, Drilling and Extraction were stablishing wells to procure crude oil and natural gas from subterranean or subaqueous sources. Normally the principal participants are Geologists, drilling engineers, and seismic specialists. The upstream sector is full of technologies with sophisticated methods like horizontal drilling, hydraulic fracturing, and seismic imaging.

Nevertheless, Midstream Sector major related to the tasks of conveyance and storage. The transportation and conveying actively manage on the crude oil, natural gas, and refined goods via pipelines, vessels, railways, and vehicles. Next, storage, particularly like infrastructure such as tanks and terminals, is utilized for the retention of oil and gas products prior to processing or distribution. Therefore, processing involves preliminary refinement and treatment to eliminate contaminants, guaranteeing that the raw material complies with market standards. Midstream important after the upstream sector.

Downstream Sector is the refinement and marketing also the procedure of transforming crude oil into functional products including gasoline, diesel, jet fuel, and petrochemicals. Downstream significantly in marketing and distribution: The sale of items to end-users, encompassing individuals, industries, and governmental entities. While the onshore fabrication can be at downstream or upstream sector in order to construct and fabricate the platform as Figure 2 of exploration and refinement. Fabrication for offshore structures and platform fabrication emphasizes the construction of durable structures for upstream oil and gas operations. The two main components manufactured are jackets and top sides. Jacket fabrication objective is to Ensures structural integrity by securing the platform to the seafloor. It involves the procedure of cutting, rolling, and welding steel to construct the jacket framework. Then, treatments for corrosion resistance against seawater exposure has to be considered due to highly impacted on the quality. Temporary erected and fabricated after all it requires loading and transportation to offshore installation locations to its final destination. Generally, illustrative applications and demand by Clients from Onshore Fabricator are Fixed platforms, wellhead platforms, and riser platforms. Next, the topside fabrication objective are to accommodate all operational apparatus and crew. Whilst the procedure and installation of components are gas compressors, separators, power systems, electrical and plumbing connections for optimal functionality. Finally, thorough evaluation prior to implementation.

The workers of Oil and Gas Industry well know their industry for the above 3 major sectors and make an impact on the country in terms of economic . The industry produces substantial money and jobs while propelling global trade (Clews, 2016).

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Figure 2: Overview of Fabrication O&G Projects
Source: Mohd Roshdi, F.R,2023

Onshore fabrication projects in the oil and gas industry face unique challenges that make it essential to focus on cognitive ergonomics. Workers in these settings often deal with physically and mentally demanding tasks, increasing the risk of safety incidents and impacting productivity. Despite advancements in physical ergonomics, the mental resilience required for such environments is underexplored. Addressing cognitive aspects can significantly improve worker well-being and operational efficiency. By understanding how cognitive ergonomics affects onshore fabrication, this research can develop strategies to enhance safety and productivity, aligning with international goals for sustainable industrial innovation. Menon and Bhagat (2023) explore motivation theory, which is essential in considering cognitive ergonomics within workplace environments.

Despite recognized benefits, there is a notable gap in practice concerning the specific interactions of these ergonomic risk factors in this context. The core research problem is the insufficient exploration of how cognitive ergonomics influence worker safety and efficiency in onshore fabrication projects, where both physical demands and mental resilience are critical. By focusing on this problem, the research aims to generate qualitative insights that fill existing gaps in the literature, contributing to tailored ergonomic strategies that improve the well-being and performance of workers in onshore fabrication projects. This directly addresses the interplay of ergonomic risk factors, leading to broader advancements in occupational health and safety.

Result and Analysis

Qualitative data typically consists of extensive text derived from interviews, observations, and empirical sources with Ask, Record, Confirm (ARC) techniques with Focus Group Discussion (FGD) (Zairul, M., 2019). However, not all of the text may be the study's output instead, part of it may. Consequently, the data must be managed meticulously and appropriately. Zairul, M. (2021) asserts that qualitative data analysis involves describing and summarizing text, drawing conclusions from the data, and facilitating the interpretation of outcomes related to prior research. The information in the Thematic in Atlas Ti Version 24 reveals three main themes as per Figure 3.

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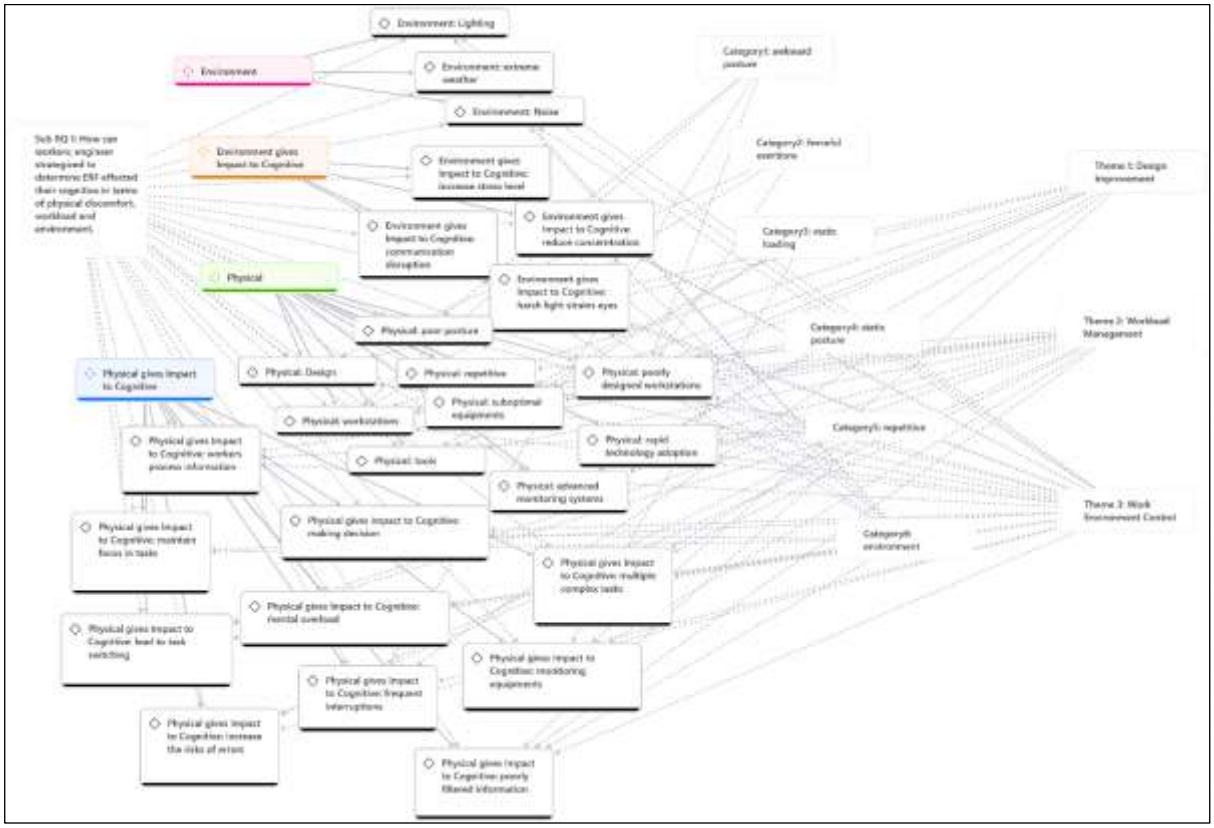

Figure 3: Thematic Analysis thru Atlas Ti Version 24

Theme 1: Design Improvement reflects to this theme emphasizes the use of ergonomic workstations, tools, and postural support to lessen physical strain. Regarding the Enhancement in Ergonomic Design, the use of ergonomic strategies to reduce physical strain and encourage cozy positions. This theme emphasizes the development of ergonomic equipment, workspaces, and workflows to reduce physical strain and encourage pleasant working postures. Configure workstations to accommodate workers' height and reach, hence reducing bending and stretching. Thus, adjustable welding tables and scaffolding facilitate the maintenance of neutral postures for workers during operations.

Theme 2: Workload Management reflects to reduce mental fatigue and frequent task switching, a focus is made on striking a balance between task complexity and manageable workloads. Put cognitive load management techniques into practice with the use task management techniques to improve decision-making effectiveness and lessen mental overload. This theme underscores the importance of balancing task complexity and intensity to mitigate mental weariness and improve decision-making efficacy. Task Simplification decomposes intricate work into smaller, manageable components. Modular fabrication disaggregates huge projects into smaller components to facilitate assembly. In addition, in reducing cognitive tiredness and stress levels. Therefore, enhanced decision-making, precision in job performance, enhanced efficiency and uniformity throughout project timelines.

Theme 3: Work Environment Control reflects in improving environmental elements including temperature regulation, noise reduction, and illumination to promote improved wellbeing and cognitive performance. Next, improvement in the surroundings are to lessen cognitive fatigue,

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manage noise, make sure the lighting is optimal, and maintain proper climate control. This theme addresses environmental variables that influence physical and cognitive function, including illumination, temperature, and auditory levels. Besides, sound mitigation is implementing sound-dampening barriers or supply noise-canceling headsets to mitigate auditory distractions. Isolating loud machinery within soundproof chambers to enhance communication and concentration. Thus, implement adjustable task lighting to mitigate glare and shadows whereas LED lighting solutions deliver uniform illumination, improving vision for meticulous activities. However, ventilation systems and cooling garments for elevated temperatures, heating devices for low temperatures can facilitate adequate ventilation to minimize exposure to vapors or particulate matter. Finally, by utilizing targeted exhaust systems in welding zones to eliminate detrimental particles.

The three areas are interrelated, collectively enhancing ergonomic excellence in onshore fabrication projects are design enhancement improves physical comfort, diminishing physical weariness that may indirectly impact mental concentration. Workload Management prevents cognitive overload in workers, enhancing the physical advantages of ergonomic design. The management of the work environment fosters a conducive setting that enhances both physical and cognitive performance.

Conclusion

The amalgamation of design enhancement, workload oversight, and work environment regulation establishes a comprehensive ergonomic approach for onshore fabrication initiatives. This strategy addresses physical, cognitive, and environmental aspects to maintain worker health, efficiency, and focus, hence improving project safety, productivity, and quality. Important cognitive functions like information processing and decision-making are directly impacted by the interaction of environmental and physical factors. For instance, inadequate equipment and badly built workstations hinder employees' ability to process information, which raises the possibility of making mistakes. While advanced monitoring systems might increase productivity, they can also cause cognitive difficulties if they are poorly designed or excessively complicated. The results show that physical, cognitive, and environmental elements interact strongly, requiring a comprehensive approach to workplace design. These changes will boost overall productivity and employee happiness in addition to improving cognitive function.

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