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Application of Job Safety Analysis (JSA) to Mitigate Ergonomic Risks in Visual Communication Design Vocational High School

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Abstract

This study aimed to identify ergonomic hazards and assess occupational health risk levels among Vocational High School students in the Visual Communication Design program. Using a qualitative approach with 32 Grade XII participants, data were collected through participatory observation of 10 critical work steps and workstation measurements. The analysis, mapped into a Job Safety Analysis (JSA) matrix, revealed significant facility dimensional gaps that forced postural compensation. Results indicated that 60% of work steps were classified as High Risk, with the highest risk scores (R=15) identified in repetitive mouse usage and long-duration static work. These risks were driven by an "almost certain" frequency of exposure, confirming the existence of chronic "silent hazards" within computer laboratories. While limited to a case study in Tangerang City, the findings implied that vocational environments harbour cumulative musculoskeletal risks often overlooked compared to acute safety issues. Consequently, the study recommended administrative controls, specifically disciplined micro-breaks and the 20-20-20 visual rule as the most effective and economical mitigation strategies compared to overhauling physical facilities. This research emphasized the urgency of establishing a healthy work culture for the future creative workforce. Its novelty lay in adapting JSA methodology to detect preventive health risks in non-technical Vocational High School settings, distinct from the conventional focus on physical safety in heavy industries.

Keywords: Job Safety Analysis, Ergonomics, Desain Graphic, Risk Mitigation, Vocational High School.

1. Introduction

Vocational education, particularly in Vocational High Schools (VHS), holds a primary mandate to produce competent and work ready graduates aligned with the demands of the Business and Industrial World. This work readiness encompasses not only the mastery of hard and soft skills but also the internalization of a strong Occupational Health and Safety (OHS) culture [1]. The current modern OHS paradigm is no longer reactive; rather, it demands a proactive approach through systematic risk management to prevent accidents and occupational diseases before they occur [1].

However, this ideal condition is not yet fully reflected in practice. Attention to OHS within the Vocational High School environment is often biased and concentrated on study programs perceived to carry high physical risks, such as machining or welding engineering. Meanwhile, “the hidden hazards” inherent in computer-based programs are frequently overlooked. The Visual Communication Design (VCD) program represents a field experiencing rapid growth in line with the demands of the creative industry. In reality, VCD students spend the majority of their learning hours in static postures in front of computers, performing repetitive movements while designing graphics or editing videos [2]. The urgency of this research is underscored by the increasing prevalence of occupational health risks in the vocational education sector, particularly regarding ergonomic hazards. This condition presents unique OHS challenges, specifically ergonomic risks which, without proper intervention, these behaviors can lead to chronic injuries such as Musculoskeletal Disorders (MSDs) and Carpal Tunnel Syndrome (CTS), eye strain, and long-term postural issues ultimately reducing productivity [3], [4].

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Despite the critical importance of safety in vocational training, a significant gap exists in the current literature. Literature studies indicate that ergonomic deficiencies in the physical design of computer workstations and poor work practices are significant causes of back, neck, and eye complaints among computer users [5], [6]. Moreover, studies have identified a critical gap between ergonomic knowledge and daily practices among computer users that triggers health hazards [6], [7]. To address this, systematic approaches such as participatory ergonomic interventions have proven effective in reducing MSD complaints [3], [8]. This effectiveness is further enhanced when combined with the Job Safety Analysis (JSA) method, which is capable of identifying hazards in detail at the job-step level [9], [10]. The integration of ergonomic methods with JSA and risk assessment (Risk Score) has proven valid in improving the accuracy of hazard identification in the industrial sector. Previous studies on Job Safety Analysis (JSA) have predominantly focused on high-risk heavy industries, such as manufacturing, mining, and construction [1], [11]–[15].

Although the effectiveness of JSA is well established in the industrial sector, a distinct research gap remains within the context of vocational education. There is a paucity of research specifically applying JSA methodologies within the educational environment of Vocational High Schools especially in "clean" laboratory settings like computer labs for design subject. Most existing research in schools tends to focus on general safety management rather than specific hazard identification techniques like JSA. This study aims to bridge this gap by adapting the JSA framework to identify, analyse, and mitigate cost-effective ergonomic mitigation risks specifically for VCD students, and suitable for implementation in vocational education.

2. Method

This study utilized a descriptive research method with a case study approach. This approach was selected to provide an in-depth, detailed, and holistic overview of the real-world situation regarding the application of Job Safety Analysis [9], [10] in identifying ergonomic risks [4], [16] within a specific context, namely the Visual Communication Design practice laboratory (Figure 1). The primary focus of the research was to analysis student work activities and formulate relevant risk mitigation strategies.

Figure 1. Visual Communication Design Laboratory at Vocational High School of ABC

2.1 Object and Subject Research

The research was conducted at the Computer Laboratory of the VCD Program at a selected Vocational High School in Tangerang City, Banten Province. This location was selected based on preliminary observations indicating the high duration of computer usage by students and the availability of representative facilities for VCD learning. The study spanned three months, from August 2025 to October 2025, encompassing the preliminary study, observation, data analysis, and the formulation of recommendations.

The subjects of this study invloved 32 grade XII of Visual Communication Design students from the Visual Communication Design program at vocational High School of ABC (Table 1). The sampling technique employed was purposive sampling. The age of the participants ranged from 17 to 19 years.

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The object of the research focused on the 'Graphic Design Using Computer' work activity along with the accompanying potential ergonomic risks [4], [6], [16]–[20].

Table 1. General Data of the Research Subject

School Data	Description
School Name	Vocational High School of ABC
Address	Tangerang City, Banten Province
Year Established	2003
Total of Students	432 students
Grade	XII VCD
Number of Students	32 students
Number of Male Students	28 students
Number of Male Students	4 students
Age Range	17-19 years old
Computer Duration Range	4-6 hours/day

Ethical approval for this study was granted by the school administration, and written informed consent was obtained from all participants. The participation was voluntary, and students were assured of their anonymity and right to withdraw from the study at any time without consequence.

2.2 Research Procedure

The research procedure was conducted through four systematic stages. First, preliminary observation, which involved conducting observations in the laboratory to identify dominant work activities and conducting brief interviews with vocational subject teachers. Based on this stage, the activity of "Graphic Design Using Computer" was established as the critical task to be analyzed. Second, analyzing the selected job by decomposing it into 10 detailed work steps. The researcher conducted participatory observation as students performed each step to identify potential ergonomic hazards. hird, formulating risk control recommendations focusing on administrative and engineering controls for each identified hazard. The final step involved discussing the JSA findings (hazards and mitigations) [9], [10], [21] with Visual Communication Design vocational teachers for contextual validation, followed by analysing all data to draw conclusions.

2.3 Instruments dan Research Tools

The primary instrument utilized was the JSA worksheet in a matrix format, comprising columns for Job Steps, Potential Hazards/Risks, and Control Measures/Mitigation (Table 2) [10].

Table 2. Job Safety Analysis (JSA) Table

No.	Job Steps	Hazard Identification	Potential Hazard/Risks	Risk Mitigation
1.				

Supporting equipment included hardware (all in one PCs, standard optical mice, keyboards, tables, and student chairs), graphic design software (such as Adobe Illustrator and Photoshop), and measuring instruments (measuring tape and ruler) used to assess workstation dimensions (table height, chair height, and monitor distance) to provide supporting data for the ergonomic analysis (Figure 2).

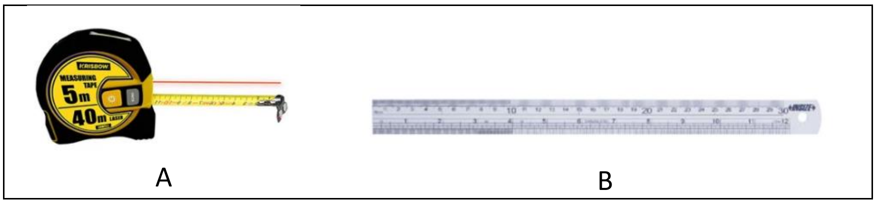

Figure 2. Measuring Instruments: a) Tape, b) Ruler

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2.4 Data Analysis Technique

Qualitative data analysis employed the Miles & Huberman model, encompassing data reduction (sorting observation notes into JSA forms), data display in the form of JSA tables, and conclusion drawing (verification) as shows Table 3 [22]. Risk level assessment was conducted semi quantitatively based on two primary parameters: Likelihood (L) and Severity (S). The risk value was calculated using the formula: Risk = Likelihood x Severity. The resulting scores were subsequently categorized into a risk matrix to determine the priority of control measures, ranging from low, medium, high, to very high levels (Table 4).

Table 3. Risk Assessment Method Based on Likelihood

Level	Category	Description
1	Rare	An event that is very unlikely to occur under extraordinary conditions, usually a long time without occurring[1]
2	Unlikely	An event that has a low probability of occurring in a particular situation[2]
3	Moderate	An event that has the potential to occur under several possible circumstances[3]
4	Likely	This is quite common in most situations[4]
5	Almost certain	An event that is almost certain to occur in every situation or in all activities carried out by an organization[5]

Source: (Yunandro Markus & Djunaidi, 2024)

Table 4. Risk Assessment Methods Based on Severity

Level	Category	Description
1	Insignificant	The impact does not cause injury and/or only causes very minor material damage[1]
2	Minor	The impact requires first aid or minor treatment and/or causes moderate material damage[2]
3	Moderate	Requires medical treatment resulting in loss of work time, e.g. requiring temporary rest and/or causing significant material damage[3]
4	Major	Resulting in loss of bodily function (disability) and/or partial cessation of work processes, and also causing major material losses[4]
5	Catastrophic	Potential to cause death and/or result in enormous material losses[5]

Source: (Pardede et al., 2025)

The risk levels obtained after analysis based on Likelihood and Severity can be further categorized in the risk matrix in Table 5.

Table 5. Risk Matrix

Risk Analysis Matriks		Likelihood Level				
		1	2	3	4	5
		Rare	Unlikely	Moderate	Likely	Almost
Severity	1. Insignificant	1	2	3	4	5
	2. Minor	2	4	6	8	10
	3. Moderate	3	6	9	12	15
	4. Major	4	8	12	16	20
	5. Catastrophe	5	10	15	20	25

Source: (Sukwika & Pranata, 2022)

Table 6. presents the interpretation of the risk values obtained from the assessment matrix, which categorizes risk scores into four priority levels of action. A risk score at the "Low" level (0-4) is considered an acceptable or tolerable risk, thus requiring no specific control intervention. A "Medium"

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level (5-9) indicates the need for planning control measures to reduce the risk level. Meanwhile, the "High" level (10-16) requires the implementation of high-priority and immediate control measures to address the source of the hazard. The highest level, "Very High/Extreme" (score >16), is classified as an emergency situation that requires immediate control measures because the potential hazard must be addressed as a top priority. Determining these categories is very important in the risk control hierarchy to prevent incidents or work accidents.

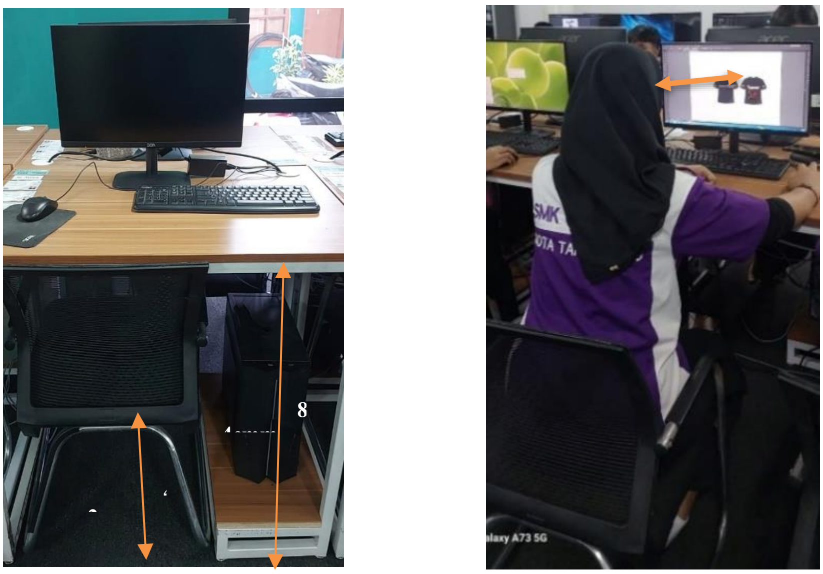
Table 6. Risk Scores, Categories and Risk Mitigation

Risk Score	Category	Color Indicator	Description
>16	Very high/extreme	Dark red	Hazard management requires immediate intervention through control measures. This situation is categorized as an emergency with the highest priority[1]
10-16	High	Red	Control interventions must be executed immediately to address the root causes of the hazard. This is a high priority to avoid more severe impacts[2]
5-9	Medium	Yellow	Planned steps are needed in managing hazards to reduce the risk level to a lower level[3]
0-4	Low	Green	The risk is tolerable because the potential danger is low, so it does not require special control intervention[4]

3. Result and Discussion

3.1 Result

Based on direct observations conducted during the students' graphic design activities, data were obtained regarding the physical dimensions of the research subjects and the dimensions of the work facilities utilized. Measurements were performed to identify the compatibility between the physical facilities (engineering) and the users' body postures. The results of anthropometric measurements on 30 students revealed significant variation in body height, ranging from 155 cm to 179 cm. This variation indicated that the user population possesses diverse requirements regarding reach and height. However, the available workstation facilities were static (non-adjustable). Facility measurement results showed that the average chair height was 42 cm and the computer table height was 84 cm, as shown in the Figure 3 below:



a b
Figure 3. a) PC Unit, Chair and Table, b) Students Designing on Computer

These data indicate a vertical gap of 42 cm between the chair seat and the table surface. This condition creates an ergonomic mismatch, given that the ideal standard for the height difference between

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a chair and a computer work table generally ranges from 27 to 30 cm. As a consequence of the table being excessively high relative to the chair (84 cm versus 42 cm), visual observations revealed that the majority of students particularly those with heights near the lower limit (155 cm) tended to perform postural compensation in the form of shoulder elevation and arm abduction to reach the keyboard and mouse on the Table 7.

Meanwhile, measurements regarding visual interaction indicated that the student's eye-to-monitor distance fell within the range of 55–60 cm. Generally, this distance remains within the visual ergonomic tolerance threshold (50–70 cm). However, due to the elevated table position, students with shorter statures were observed tilting their heads upward or stiffening their backs rigidly to obtain an optimal viewing angle of the monitor, contributing to a static load on the neck and lower back areas.

A summary of workstation dimensions and student anthropometric data is presented in the following Table 7:

Table 7. Workstation Dimensions and Research Subject Data

Measurement Parameters	Measurements Results (Average/Range)	Remarks
Student body height	155 – 179 cm	User height variation (heterogeneous).
Computer table height	84 cm	Fixed, classified as high for seated work.
Chair height	42 cm	Fixed, non-adjustable height.
Difference (table - chair)	42 cm	The gap is too large, triggering raised shoulders.
Eye-to-monitor distance	55 – 60 cm	Within reasonable visual tolerance limits.

Based on the results of participatory observation in the VCD laboratory and validation with vocational subject teachers, the activity 'Graphic Design Using Computer' was established as the most critical job (Figure 4). This selection was based on two primary factors: the work duration, which dominated student practical hours (reaching 4–6 hours per day), and its high relevance to physical complaints reported by students, specifically back pain, neck stiffness, wrist and finger stiffness, and eye fatigue.

Figure 4. Graphic Design Activity Using Computers

To conduct a comprehensive risk analysis using the JSA method, this complex activity was decomposed into a more specific sequence of work steps. This decomposition process was crucial to isolate ergonomic hazards potentially concealed within each micro-stage, ranging from initial preparation to prolonged work processes. The decomposition results identified 10 primary work steps performed sequentially by the students. These stages commenced with the workstation preparation phase (steps 1–4), covering chair and monitor adjustments, followed by the software interaction phase (step 5), and extending to the core design phase (steps 6–9), which involved intensive keyboard and mouse usage. The final step (step 10) identified the long-duration static work phase as a single critical activity unit.

Complete details of these work steps, along with descriptions of the observed activities, are presented in Table 8 below:

Table 8. Critical Work Steps in Graphic Design Activities for VCD Students

No.	Job Steps	Activity Description
1	Powering on the computer	Reaching for the CPU power button or electric switch in the under-table area.
2	Adjusting the chair	Adjusting seat height and backrest position before sitting.
3	Adjusting the monitor	Adjusting viewing distance and screen tilt angle to be at eye level.
4	Positioning input devices	Placing the keyboard and mouse for easy hand reach.
5	Launching software	Login process and waiting for design applications to load (body leaning forward).
6	Typing (keyboard)	Inputting text and pressing shortcut keys with fingers.
7	Operating the mouse	Cursor navigation, drawing, and drag-and-drop operations with repetitive wrist movements.
8	Reviewing design details	Staring at the screen statically and intensively to inspect visual details.
9	Searching for design references	Staring at the screen statically and intensively to inspect visual details.
10	Long duration static work	Sitting sedentarily in the same position for > 4 hours without breaks.

The analysis proceeded by mapping potential hazards at each stage and determining relevant control measures. Table 9 below presents the complete JSA matrix, integrating hazard identification with mitigation recommendations based on administrative and technical controls

Table 9. JSA Matrix and Ergonomic Risk Mitigation

No.	Job Steps	Hazard Identification	Potential Hazards/Risks	Risk Mitigation
1	Powering on the Computer	Power button is located on the CPU under the table; access is obstructed.	Extreme bending posture, risk of back injury.	Admin: Educate on safe squatting techniques. Technical: Relocate CPU to the tabletop if possible.
2	Adjusting the Chair	Static chair features (fixed height at 42 cm), non-adjustable.	Legs dangling for shorter students (<160 cm); pressure on the lower thighs.	Technical: Provide simple footrests made of wood or used boxes.
3	Adjusting the Monitor	Monitor placed on an 84 cm high table. Screen position tends to be too high for seated students.	Neck looking up (extension), rapid eye fatigue (eye strain).	Admin: Implement viewing distance rule of 50–70 cm. Technical: Adjust monitor tilt downwards.
4	Positioning Input Devices	Table is too high (42 cm difference from chair). Student elbows bent sharply (<90°).	Shoulders forced into a raised position permanently during work.	Admin: Instruct to "Relax Shoulders" periodically. Technical: Use additional seat to elevate the student's position.
5	Launching Software	Waiting for loading with body leaning forward resting on the table.	Contact stress: Hard table edge pressing against wrists/forearms.	Admin: Habituate leaning back fully in the chair while waiting for the system to be ready.
6	Typing (Keyboard)	Wrists bent upwards (extension) due to high keyboard position.	Extensor tendon tension, risk of Tendinitis.	Admin: Keep wrists straight and "floating", utilize shortcuts.

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7	Operating the Mouse	Repetitive movements with bent wrists rubbing against the high table.	High risk of Carpal Tunnel Syndrome (CTS), severe wrist pain.	Technical (Priority): Mandatory use of Gel Mouse Pads.
8	Reviewing Design Details	Staring at a static screen; students tend to push head forward to see details.	Computer Vision Syndrome (CVS), stiff neck.	Admin: Apply 20-20-20 Rule, use zoom feature (instead of pushing head forward).
9	Searching for Design References	Looking down at phone/book placed flat on the table.	Text Neck Syndrome, neck load increases 2-3x fold.	Technical: Use a book stand/holder. Admin: Lift reference material to eye level.
10	Long-Duration Static Work	Static sitting >4 hours on a hard chair without adequate lumbar support.	Lactic acid buildup, Low Back Pain (LBP), general fatigue.	Admin: Micro-breaks every 30-45 minutes (1-2 minutes stretching) for blood circulation.

Subsequently, each of the aforementioned hazards was assessed for its risk level using the Likelihood (L) and Severity (S) parameters to obtain the Risk Score (R). The calculation results are presented in Table 10 below:

Table 10. Quantitative Risk Assessment Results

No.	Job Steps	L	S	R	Risk Category
A	Powering on the computer	3	3	9	Medium
B	Adjusting the chair	4	3	12	High
C	Adjusting the monitor	5	2	10	High
D	Positioning input devices	4	2	8	Medium
E	Launching software	3	2	6	Medium
F	Typing (keyboard)	4	3	12	High
G	Operating the mouse	5	3	15	High
H	Reviewing design details	5	2	10	High
I	Searching for design references	4	2	8	Medium
J	Long-duration static work	5	3	15	High

Note: L = Likelihood (1–5), S = Severity (1–5), R = Risk Score (L × S)

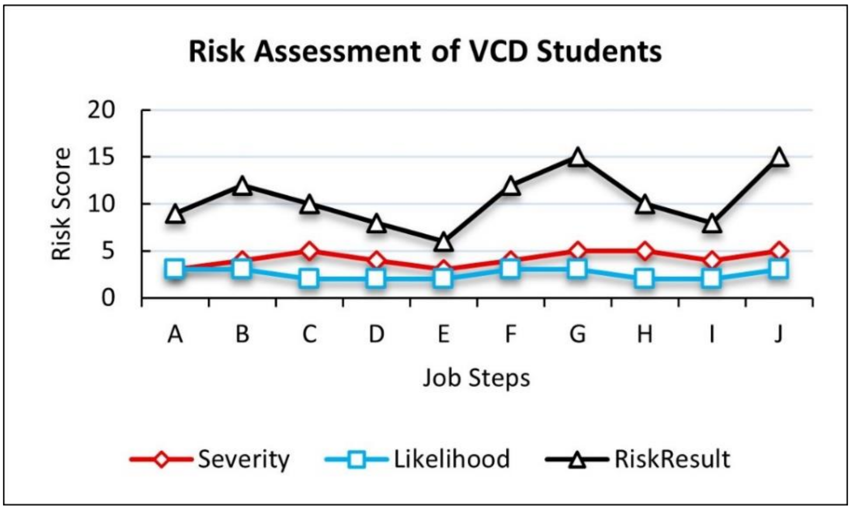

Figure 5. Risk Score Chart

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- Risk Assesment Findings:

Based on the analysis results of the 10 job steps, quantitative findings indicate that no activities were categorized as 'Low Risk.' The identified risk distribution revealed that 60% (6 out of 10 steps) fell into the High Risks category, while 40% (4 out of 10 steps) fell into the Medium Risk category. The most significant finding was the highest risk score (R=15), situated at the upper limit of the 'High' category, identified in two crucial activities: 'Operating the Mouse' (L=5, S=3) and 'Long-Duration Static Work' (L=5, S=3). Both activities were assessed as having an 'Almost Certain' Likelihood (L=5) of occurring in every practical session, with a 'Moderate' Severity impact (S=3). Furthermore, other high risks were observed in fundamental activities that determine student work posture, specifically chair adjustment (R=12), keyboard usage (R=12), and monitor adjustment (R=10) as shows Figure 5.

3.2 Discussion

The dominance of chronic exposure in the vocational education environment. Data analysis indicates that 60% of the work steps performed by Visual Communication Design students fall into the 'High Risk' category. This finding fundamentally confirms that hazards in Vocational High School computer laboratories are not acute (immediate) in nature, but rather chronic (accumulative). The high risks scores observed in mouse usage and static sitting activities (R=15) are driven entirely by the maximum Likelihood value (L=5 or 'Almost Certain'). This aligns with studies stating that physical complaints among computer users correlate linearly with exposure duration, where usage exceeding four hours triggers significant complaints in the shoulders and back [4], [6], [18], [23].

However, this study deepens these findings within the specific context of vocational adolescents. While Shikdar [18] focused on adult office employees, this research reveals that vocational students aged 17–19 years are already exposed to ergonomic risk levels equivalent to professional workers, due to intense curriculum demands (4–6 hours/day) [3], [4], [8], [23]. This indicates that musculoskeletal degeneration may commence significantly earlier than previously anticipated.

The novelty aspect of this research is evident when comparing the risk characteristics of VCD students with traditional OHS research in vocational or manufacturing industrial environments. Studies [1], [3], [8], [11]–[13], [17], [24]–[27] various industrial sectors demonstrate that the primary focus of JSA in those sectors is to prevent high-Severity risks (such as permanent disability or fatality), even if the Likelihood might be moderate. Conversely, this research on VCD students uncovered a diametrical risk pattern: Severity tends to be low (Minor/Moderate), yet the Likelihood is extreme. The novelty of this study lies in the successful adaptation of the JSA methodology typically utilized for physical safety into an effective tool for preventive occupational health within the educational environment. This research demonstrates that JSA is capable of detecting 'Silent Hazards' that are frequently overlooked in conventional OHS inspections in non-technical vocational schools.

The elevated risk associated with the activity of 'Operating the Mouse' (R=15) corroborates the biomechanical theories outlined by Bridger [28] dan Goggins et al. [7]. Repetitive movements accompanied by ulnar deviation (sideways bending of the wrist) during mouse usage generate pressure within the carpal tunnel. This finding is bolstered by field conditions wherein the majority of students do not utilize wrist rests, resulting in direct friction between the wrist and the hard edge of the table (contact stress). Meanwhile, the risk associated with 'Long-Duration Static Work' (R=15) is consistent with the study by Tarwaka [16] which states that static work postures restrict blood flow to muscles and lead to lactic acid accumulation. In the context of VCD students, this condition is exacerbated by a behavior of being 'locked' onto the monitor screen (intense visual focus), which unconsciously suppresses the body's natural mechanism to move or stretch.

Control recommendations focusing on administrative aspects (micro-breaks and 20-20-20 rules) are supported by findings from [18], [23]. These studies observed that participatory ergonomic interventions, where subjects (students) are actively involved in modifying work methods, are more effective and sustainable compared to mere equipment modifications [29]. Given that the root cause of the risk is the frequency of exposure (chronic) rather than the severity of a specific incident, the mitigation strategy is prioritized toward Administrative Controls. Although engineering controls, such as the procurement of ergonomic chairs, represent the ideal solution, this approach is frequently hindered by budgetary constraints within the school environment. Therefore, behavior change interventions through the implementation of Micro-breaks—requiring standing or stretching for 1–2 minutes every

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30–45 minutes of work—and the application of the 20-20-20 rule to rest the eyes every 20 minutes, are considered far more effective and feasible. This approach directly disrupts the static exposure cycle ('breaking the static cycle'), which is the primary cause of fatigue accumulation. This solution demonstrates that addressing ergonomic risks in schools does not always require investment in expensive equipment, but rather the development of a disciplined and healthy work culture.

In general, this discussion concludes that vocational education in the field of information technology (such as VCD) harbors a serious 'time bomb' regarding occupational health issues. Ergonomic risks in schools must no longer be viewed merely as comfort issues, but rather as threats to long-term productivity. Therefore, the integration of an OHS curriculum specifically addressing computer ergonomics and break management is imperative not merely as a supplement, but as a core competency for vocational graduates to ensure work readiness without the risk of early injury.

4. Conclusion

This study concludes that the application of Job Safety Analysis (JSA) is effective in identifying chronic ergonomic hazards among Visual Communication Design (VCD) students. Notably, 60% of work activities were classified as 'High Risk,' driven not by the severity of acute injuries, but by the 'Almost Certain' frequency of exposure associated with repetitive mouse usage and static postures. These findings underscore the urgent need to shift the focus of mitigation from mere physical facility improvements to the implementation of strict Administrative Controls specifically mandatory micro-breaks and postural discipline. These measures represent the most crucial and feasible interventions for preventing permanent musculoskeletal disorders. Furthermore, this study demonstrates the necessity for systematic preventive risk management within non-technical vocational education environments, which have historically been overlooked.

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