

Lighting study at the Universidad Tecnológica de Aguascalientes

Estudio de Iluminación en la Universidad Tecnológica de Aguascalientes

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Abstract

In the present job, the objective is to carry out an evaluation of the level of illumination in each building of the Technological University of Aguascalientes (UTA), taking as a reference the NOM-025 -STPS-2008 that is focused on illumination conditions in the work centers. The project has two parts: firstly counting and verifying the types of lighting, until the last lamp and to determinate, how much watts each building, consumes. Subsequently, an analysis was carried out with the lux meter and to be able to verify versus the parameters indicated in the NOM-025-STPS-2008 to subsequently make recommendations.

Lighting, Evaluation points, Lux, Meter, Nom-025-2008

Resumen

El presente trabajo tiene como objetivo, realizar una evaluación de los niveles de iluminación en los edificios de la Universidad Tecnológica de Aguascalientes (UTA), teniendo como referencia la NOM-025-STPS-2008, referente a las condiciones de iluminación en los centros de trabajo. El proyecto está integrado por dos partes: primeramente, se hizo un registro de los tipos de iluminación hasta el detalle de cada lámpara, y cuantificar el consumo en watts, por edificio. Posteriormente, se realizó un análisis con luxómetro para comparar contra los luxes referencia de la NOM-025-STPS-2008 y emitir recomendaciones.

Iluminación, puntos de evaluación, luxómetro, Norma-25-STPS-2008

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Introduction

Workplaces require a lighting level according to the activities to be performed and in compliance with regulations, which can improve productivity, safety and comfort of workers (Marquines et al., 2020).

The level of illumination is one of the main factors where the worker can be affected by the level of fatigue and the mental state of the same, to develop their work (Machado Miranda et al., 2020). In this sense, in order to develop work activities better, it is necessary to see their environmental characteristics and vision that complement each other in 50% of the sensory information received by man of visual type, in other words, as a primary source of light. Having an evaluation of the visual aspect, we will have a better safety, comfort and productivity (Paul et al., 2022).

Casbascango Camuendo et al., (2021) mentions, distribution, intensity and balance of artificial and natural light must comply for the type of work to be performed, because if it is not met it can affect vision, irritation, as well as eye fatigue and headaches.

Lighting and ventilation must be in accordance with the needs of workers, complying with the allowed luxes required by the regulations for optimal performance (Torres Julon, 2020).

Mexican Standard 025 of the Ministry of Labor and Social Welfare (STPS) of 2008, refers that a safe and healthy work environment should be promoted in workplaces, to provide a good working environment for the worker, prevent accidents and damage to facilities, have good visibility, identify areas of opportunity; It also obliges the employer to recognize and evaluate the conditions, lighting levels in all areas and work stations, through reports and reports of the study of lighting conditions, as well as the control of the same, the maintenance of lights and luminaries, including emergency lights, among others.

Workers are obliged to notify the employer of unsafe lighting conditions, to use lighting systems appropriately, to participate and observe measures to control lighting levels based on evaluations and to take the eye exams required by the employer (Secretaría del Trabajo y Previsión Social, 2008).

Having this context of the importance of a lighting study, the Technological University of Aguascalientes (UTA), has the interest to perform in all buildings, supporting the department of Maintenance and Facilities, a lighting study.

Description of the problem

The Technological University of Aguascalientes has a quality management system, through which complaints were received from teachers, students and administrative staff about the type of lighting in the areas and workshops.

In the workshops, students practice in two shifts (morning and afternoon) and poor lighting can cause accidents. In the case of administrative areas and classrooms, it can cause visual fatigue (Torres Julon, 2020). Upon reviewing such a claim, the absence of a lighting study of the institution became notorious,

Project objective

To carry out a study of the UTA facilities according to regulation 025-STPS-2008, in order to comply with the lighting according to the activity performed.

Methodology to be developed

There are two methods in the implementation of the project: Deming's circle and NOM-025-STPS-2008.

In the Deming Circle that serves for the analysis and solution of problems and implementation of improvements, considering: Plan, Do, Check and Act (PHVA) (Castillo Pineda, 2019). In the stages of each of them will be implemented as follows:

1. Planning (Plan); in this stage is to identify the positions to be evaluated as: (a) State of the company and its needs; (b) the type of lamps is identified, (c) the type of activities performed by personnel in each building, this was done in order to identify whether there is poor lighting or excessive lighting that can cause glare (d) description of the tasks performed (Paul et al., 2022).
2. Doing (Do); when the activities are established, work begins on the changes to achieve the objectives that were set. In the Do stage, the analysis of the type of lamps, their height and the study of luxes that exist within the facilities will be carried out.

The lighting study will be supported by the NOM-025-STPS-2008, considering the "appendix A" (evaluation of lighting levels), as well as the reference guide "I" (measurement of lighting levels), both references, which are part of the standard itself.

Within the reference "I", it handles the method to evaluate the average illumination levels, with the purpose of verifying the values corresponding to an installation, precautions must be considered to carry out the study such as: Nominal voltage supply, ambient temperature, choice of lamps, so that the readings of the illuminance meter are corrected taking into account the conditions.

To determine the average illuminance calculation for the building constant method, the following expression is used (Secretaría del Trabajo y Previsión Social, 2008):

$$E_p = 1/N (\sum E_i) \quad (1)$$

Where:

E_p = Average level in lux.

E_i = Illumination level measured in lux at each point.

N = Number of measurements made.

With this calculation the average will be determined to establish if the work area has the lux required by the standard (Secretaría del Trabajo y Previsión Social, 2008).

Check; in this stage it is verified if the improvements made, serve to achieve an objective; it is verified if the data obtained with the luxmeter are suitable according to the parameters of the norm.

Act; the results obtained in the verification phase allow to determine actions to ensure that the lighting in all UTA facilities comply with the standards indicated in NOM 25.

Project development

The next step was to make the plans of the 20 buildings (See Illustration 1) to identify the measurement points, measurement performed, with a luxmeter (measuring instrument that allows to measure simply and quickly the real and not subjective illuminance of an environment) (PROTEGER I.P.S, 2018) and this compare it with the table of lighting levels mentioned above.

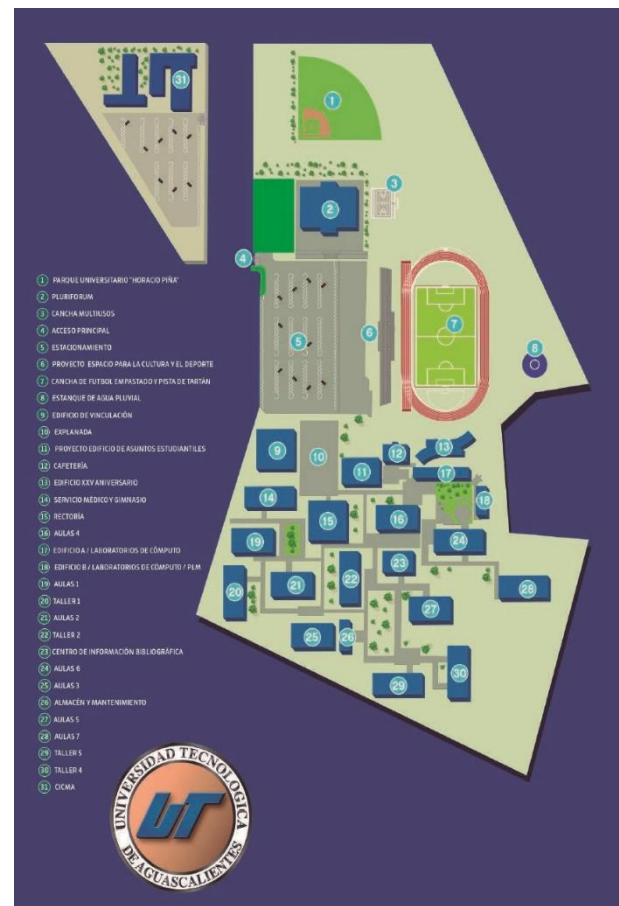
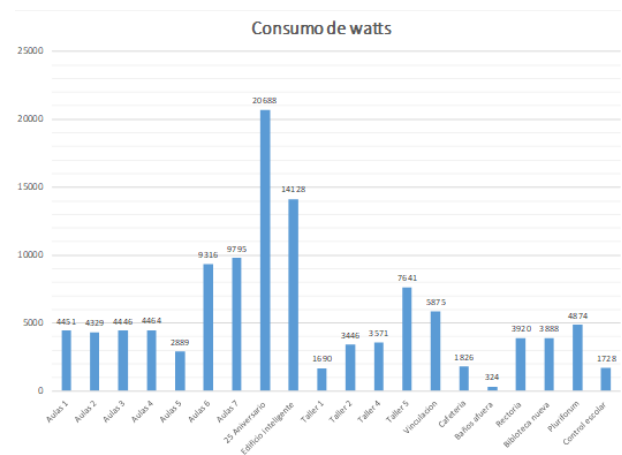


Figure 1 Plan of the Universidad Tecnológica de Aguascalientes

In accordance with STPS Norm 25, an inventory of all the lamps must be made, which in this case are 20 buildings that the university has: eight classrooms, five storerooms, four administrative areas, a sports area, restroom area and the cafeteria, to identify the number of lamps, their watts consumption, the type of luminaire and consumption (See Table 1).

Once the data on the areas were available, an analysis of watts consumption was made, where it can be seen that the highest consumption is in building XXV, the second highest consumption is in the intelligent building, and the areas with the lowest consumption are the restrooms, school control building and cafeteria (See Graphic 1)

AULAS 1					
Áreas de estudio	Lamparas	Focos	Consumo total (Watts)	Tipo de luminaria	Consumo unitario por lámpara (Watts)
Pasillos salones	20 PZA (T8)	0	360	Tubos LED	18 w
Salon 1	18 PZA (T8)	0	324	Tubos LED	18 w
Salon 2	18 PZA (T8)	0	324	Tubos LED	18 w
Salon 3	18 PZA (T8)	0	324	Tubos LED	18 w
Salon 4	18 PZA (T8)	0	324	Tubos LED	18 w
Salon 5	18 PZA (T8)	0	324	Tubos LED	18 w
Salon 6	18 PZA (T8)	0	324	Tubos LED	18 w
Salon 7	18 PZA (T8)	0	324	Tubos LED	18 w
Baños H	4 PZA (T8)	0	72	Tubos LED	18 w
Baños M	4 PZA (T8)	0	72	Tubos LED	18 w
Audivisual	18 PZA (T8)		324	Tubos LED	18 w
Pasillo de oficinas	12 PZA (T8)	0	216	Tubos LED	18 w
Pasillo recepción	8 PZA (T8)	4	180	Tubos LED y downlight	18 w y 9 w
Sala de maestros	20 PZA (T8)	0	360	Tubos LED	18 w
Oficinas	30 pza (T8)	2 (DICROSICOS)	590	LED	18 w y 25 w
Cuarto de limpieza		0 1 (9W)	9	Downlight	9 w



Graphic 1 Watt consumption of the UTA buildings

Note: A part of what was done in the UTA is represented

The next step was to identify the parameters that will be used later to see if the required lighting according to STPS Standard 025 is met (See Table 3).

Table 1 Inventory of Classroom Lamps 1

Another area that was evaluated was the workshops, which in this case will represent workshop 1, the inventory of lamps was 14 bulbs and 24 T8 (See Table 2).

Taller 1					
Áreas de trabajo	Lamparas	Focos	Consumo de Watts	Tipo de luminaria	Consumo unitario por lámpara (Watts)
Oficinas	2 T8, 8 T8	0	612	Tubo LED	18 w y 36 w
Baños de M	2 T8	0	36	Tubo LED	18 w
Baños de H	2 T8, 2 T8	0	108	Tubo LED	18 w y 36 w
Laboratorio de química	4 Focos	0	<		105 w
Cafetería de oficina	4 T8	0	72	Tubo LED	18 w
Área de almacén	6 Focos	0	630		105 w
Almacén de química	4 T8	0	72	Tubo LED	18 w
Parte exterior del taller	4 Focos	0	160		40 w
TOTAL			1690 W		

Table 2 Inventory of lamps in workshop 1

Niveles de iluminación		
Tarea visual	Área de trabajo	Niveles mínimos de iluminación (luxes)
En exteriores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículo.	Exteriores generales: patios y establecimientos.	20
En interiores: distinguir el área de tránsito, desplazarse caminando, vigilancia, movimiento de vehículos.	Interiores generales: almacén de poco movimiento, pasillo, escaleras, establecimientos cubiertos, labores en minas subterráneas, iluminación de emergencia.	50
En interiores	Área de circulación y pasillos; salas de espera; salas de descanso; cuarto de almacén; plataformas; cuarto de calderas.	100
Requerimiento visual simple: inspección visual, recuento de piezas, trabajo en banco y máquina.	Servicios al personal: almacenaje rudo, recepción y despacho, casetas de vigilancia, cuartos de compresores y pailería.	200
Distribución moderada de detalles: ensamble simple, trabajo medio en banco y máquina, inspección simple, empaque y trabajo de oficina.	Talleres: áreas de empaque y ensamble, aulas y oficinas.	300
Distribución clara detalles: maquinado y acabado delicado, ensamble de inspección moderadamente difícil, captura y procedimientos de información, manejo de instrumentos equipo de laboratorio.	Talleres de precisión: salas de computo, áreas de dibujo, laboratorios.	500
Distribución final de detalles: maquinado de precisión, ensamble e inspección de trabajo delicados, manejo de instrumento y equipo de precisión, manejo de piezas pequeñas.	Talleres de alta precisión: de pintura y acabado de superficies y laboratorios de control de calidad.	750
Alta exactitud en la distinción de detalles: ensambles proceso e inspección de piezas pequeñas y complejas, acabado con audidos finos.	Proceso: ensamble e inspección de piezas complejas y acabadas con pulido fino.	1000

Table 3 Lighting levels

Results

A table was made where information is concentrated according to NOM-025-ST5-2008 such as: Incident light, permissible level, lux reflected at the approximate height (E1), incident light (E2, lux reflected at the approximate height, incident lux among other things, in order to see if the allowed luxes were met or if they are deficient, an example of an area is attached (See Table 4), in order to avoid physical risks with vision, since they can cause occupational diseases, such as asthenopia, since one of the most relevant risks is lighting (Martínez Martínez Danna, Ramírez Torres & Yiseth, 2021).

For the case of the four workshops, a representation of the results of workshop 1 is shown, detailing the 64 points that were evaluated depending on the work areas (See Illustration 2).

ID	Área a donde se encuentra	Luz incidente n°8	Nivel permitido n°1	Cumpl. n°1	Luz reflejada a 0.75 m altura aproximada n°2	Luz reflejada a 1.50 m altura aproximada n°3	Nivel permitido n°2	Nivel permitido n°3	Cumpl. n°2	Cumpl. n°3	Punto		Punto		
											Lux	Cumpl.	Lux	Cumpl.	
1	Oficina 1	28.3	350	x	0	83	0	50	x	x	38.1	111.2	34.255289	60	x
2	Ing. Sergio	121.0	350	x	0	119.6	0	50	x	x	99.9	27.1	49.925993	60	x
3	Núcleo	161.0	350	x	0	175	0	50	x	x	47.2	110.7	49.925993	60	x
4	Entorno 2	179.2	350	x	0	174	0	50	x	x	43.1	108.9	49.925993	60	x
5	Entorno 3	152	350	x	0	83	0	50	x	x	93.8	107.3	49.925993	60	x
6	Entorno 4	194	350	x	0	159.3	0	50	x	x	42	136.9	30.701754	60	x
7	Ing. Juan Carlos	200	350	x	0	205	0	50	x	x				60	x
8	Entorno 5	180	350	x	0	214	0	50	x	x				60	x
9	Entorno 6	179.2	350	x	0	177	0	50	x	x				60	x
10	Entorno 7	193	350	x	0	187	0	50	x	x				60	x
11	Entorno 8	174	350	x	0	180	0	50	x	x				60	x
12	Entorno 9	165	350	x	0	175	0	50	x	x				60	x
13	Entorno 10	152	350	x	0	140	0	50	x	x				60	x
14	Entorno 11	164	350	x	0	117	0	50	x	x				60	x
15	Entorno 12	159.2	350	x	0	83.2	0	50	x	x				60	x
16	Entorno 13	270	350	x	0	49.1	0	50	x	x				60	x
17	Entorno 14	330	350	x	0	51.6	0	50	x	x				60	x
18	Entorno 15	86.3	350	x	0	30.8	0	50	x	x				60	x
19	Entorno 16	109	350	x	0	38	0	50	x	x				60	x
20	Entorno 17	84.2	350	x	0	85.1	0	50	x	x				60	x
21	Entorno 18	93	350	x	0	89.2	0	50	x	x				60	x
22	Entorno 19	149.7	350	x	0	149.5	0	50	x	x				60	x
23	Entorno 20	173.1	350	x	0	153	0	50	x	x				60	x
24	Entorno 21	136.2	350	x	0	10	0	50	x	x				60	x
25	Entorno 22	139.3	350	x	0	41.6	0	50	x	x				60	x
26	Entorno 23	173.6	350	x	0	61	0	50	x	x				60	x
27	Entorno 24	231	350	x	0	76	0	50	x	x				60	x
28	Entorno 25	223	350	x	0	39	0	50	x	x				60	x
29	Entorno 26	201	350	x	0	73	0	50	x	x				60	x
30	Entorno 27	201	350	x	0	111.9	0	50	x	x				60	x
31	Entorno 28	360	350	x	0	37.9	0	50	x	x				60	x
32	Entorno 29	149.9	350	x	0	106	0	50	x	x				60	x
33	Entorno 30	151.2	350	x	0	30.3	0	50	x	x				60	x
34	Entorno 31	126.9	350	x	0	54	0	50	x	x				60	x
35	Entorno 32	130.3	350	x	0	66	0	50	x	x				60	x
36	Entorno 33	88.0	350	x	0	40	0	50	x	x				60	x
37	Entorno 34	119.7	350	x	0	45	0	50	x	x				60	x
38	Entorno 35	133.1	350	x	0	59.9	0	50	x	x				60	x
39	Entorno 36	89.4	350	x	0	69.9	0	50	x	x				60	x
40	Entorno 37	97.7	350	x	0	56	0	50	x	x				60	x
41	Entorno 38	101.8	350	x	0	63.3	0	50	x	x				60	x
42	Entorno 39	86	350	x	0	51.7	0	50	x	x				60	x
43	Entorno 40	122	350	x	0	16.1	0	50	x	x				60	x
44	Entorno 41	107	350	x	0	43.9	0	50	x	x				60	x
45	Entorno 42	94	350	x	0	63.4	0	50	x	x				60	x
46	Entorno 43	161.4	350	x	0	72.9	0	50	x	x				60	x
47	Entorno 44	199.3	350	x	0	47	0	50	x	x				60	x
48	Entorno 45	89.8	350	x	0	48	0	50	x	x				60	x
49	Entorno 46	61.2	350	x	0	53.8	0	50	x	x				60	x
50	Entorno 47	88.1	350	x	0	42.9	0	50	x	x				60	x
51	Entorno 48	86	350	x	0	49.1	0	50	x	x				60	x
52	Entorno 49	59.7	350	x	0	48.9	0	50	x	x				60	x
53	Entorno 50	89.0	350	x	0	44.4	0	50	x	x				60	x
54	Entorno 51	119.2	350	x	0	56	0	50	x	x				60	x
55	Entorno 52	136.9	350	x	0	55	0	50	x	x				60	x
56	Entorno 53	226.4	350	x	0	30	0	50	x	x				60	x
57	Entorno 54	226.2	350	x	0	30	0	50	x	x				60	x
58	Entorno 55	460	350	x	0	30	0	50	x	x				60	x
59	Entorno 56	380	350	x	0	30	0	50	x	x				60	x
60	Entorno 57	200	350	x	0	30	0	50	x	x				60	x
61	Entorno 58	300	350	x	0	30	0	50	x	x				60	x
62	Entorno 59	280	350	x	0	30	0	50	x	x				60	x

Table 4 Evaluation of lux level in Workshop 1

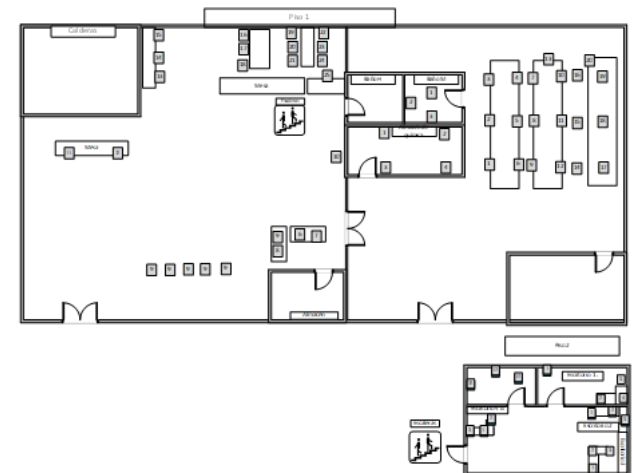
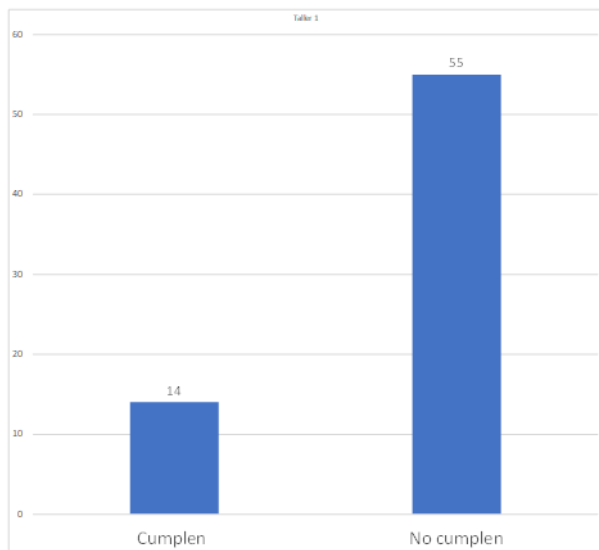


Figure 2 Evaluation of lux in workshop 1

Workshop 1

In workshop 1, the lighting of 14 points only complies with the luxes, and 55 points are below the permissible level of NOM 025 STPS 2008 (See Graph 2). It can be concluded that of the workshops (1, 2, 3 and 5), 27.14% of a total of 409 points were complied with.



Graphic 2 Luxes of Workshop 1

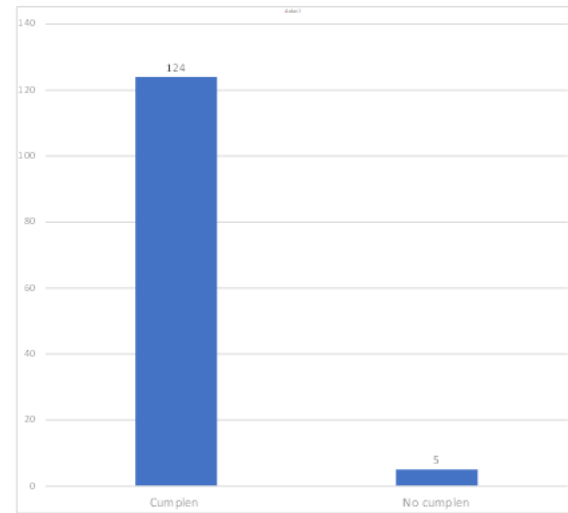
Classrooms 1

With regard to the classrooms, one is presented as "type" because they all have the same dimensions; the sampling points were determined for the lighting in the classrooms, cubicles, audiovisual, offices, teachers' lounge (See Figure 1).



Figure 3 Evaluation of lux in Classrooms 1

In classrooms 1, of a total of 129 points, 124 points complied with the luxes (See Graph 3). It can be concluded that 66.63% of the classrooms (1-6) complied with the lighting, that is, out of a total of 911 points that were taken.



Graphic 3 Classroom Luxes 1

Acknowledgements

We would like to thank the Universidad Tecnológica de Aguascalientes for the opportunity to carry out the study in their facilities. We also highlight that this study had a zero cost, since it was carried out with our own resources, and as a reference it would have had a cost of \$30,000, with an external consultant.

Conclusions

The recommendations in a very general way is to replace the luminaires in poor condition, and change the type of luminaires in the areas where the lighting levels indicated by the standard are not met, it is also required to make a maintenance and cleaning plan for the entire lighting system, in order to promote work environments that can improve productivity, safety and comfort of employees, also the design of natural lighting systems will reduce energy consumption by the combination of systems that regulate it according to the internal and external environment (Marquines et al., 2020).

The performance and learning of students is significantly influenced by the ergonomic conditions of lighting in classrooms, furniture, chair size and table height, which will be important to consider in order to make improvements in logistics (Martínez Martínez Danna, Ramírez Torres & Yiseth, 2021).

Regarding the workshops where students perform practices, it will be necessary to adapt the workplace to avoid accidents and health problems (Cabascango Camuendo et al., 2021).

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