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EDITOR'S LETTER

University community, readers, collaborators, punctually complying with our periodicity and raison d'être, we welcome you to this second ordinary and third issue of volume 14, which is already number 41 corresponding to the period June-September 2025.

It is a pleasure to address you from this space for the dissemination of knowledge and science of our Maximum House of Studies. On this occasion, we present materials from different disciplines and backgrounds, which analyse the current reality and help us understand our close environment as a fundamental part of the institution's social responsibility.

The articles are: *Prevalence and factors associated with bovine gastrointestinal parasitosis in the municipality of Mapastepec, Chiapas, Social psychology to understand the challenges of educational inclusion, Smart Cities and the Implementation of Artificial Intelligence in Autonomous Transportation – A Proposal for the City of Querétaro, Evaluation of the physical and mechanical properties of artisanal clay brick manufactured in the metropolitan area of Tuxtla Gutiérrez* and *Identification of reflective students in higher education institutions in Mexico*.

Additionally, in the Academic Documents section, we present the paper titled: Use of forearm-hand casts in Colles fractures with conservative management: A literature review.

We take this opportunity to extend the invitation to participate in the next issues and continue strengthening this university outreach body.

Sincerely:

The editors
Espacio I+D, Innovación más Desarrollo journal.

"*Por la conciencia de la necesidad de servir*"
Universidad Autonoma de Chiapas

ARTICLES

Reception: **May 2, 2024** | Acceptance: **May 12, 2025** | Publication: **June 1, 2025**

Prevalence and factors associated with bovine gastrointestinal parasitosis in the municipality of Mapastepec, Chiapas

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— Abstract—

The objective of this research was to determine the prevalence and factors associated with gastrointestinal nematodosis in cattle in the municipality of Mapastepec, Chiapas. Gastrointestinal nematodosis in cattle affects livestock health and productivity, causing great economic losses that impact the profitability of the production system. The research was descriptive and transversal. The coprological analysis of 420 samples of cattle was carried out during September - October (2023), using the flotation and McMaster technique. Non-probabilistic convenience sampling, 2x2 contingency tables, and the Chi Square test ($P<0.05$) of the SPSS IBM Statistics version 25 software were used. During this investigation, the following genera of nematodes were identified: Trichostrongylus spp., Ostertagia spp., Cooperia spp., Chabertia spp., Haemonchus spp., Strongylus spp, and Trichuris spp. Concerning the number of animals sampled, a prevalence of nematodes of 62% was found. Regarding the age groups, young cattle had a greater parasitic infestation (70.7%); Cooperia spp., being the genus with the greatest presence in young and adult animals, while in old cattle, the nematode Trichostrongylus spp was identified. The degree of parasitosis infestation in young animals was 378.3 ± 73.3 HPGH, and in adults, 219.5 ± 58.1 HPGH, being a moderate parasitosis, and in old animals, this disease was mild with 153.6 ± 10.3 HPGH. The factors associated with significant gastrointestinal nematodes in this study were: geographical area, exploitation system, breed, age, body condition, sex, animals in coexistence, and food ($P<0.05$), provided on the ranches.

Keywords:

Prevalence; gastrointestinal parasites; associated factors.

Gastrointestinal nematodosis in cattle is a multi-etiological disease caused by different genera of parasites such as Trichostrongylus spp., Haemonchus spp., Ostertagia spp., Cooperia spp., Trichuris spp., Chabertia spp., and Strongylus spp., which are worms that inhabit the digestive tract and are characterized by the following clinical signs: inappetence, anemia, edema, diarrhea, decreased production, and even death of the animal. It should be noted that the frequency of these parasites depends on various factors such as climate, management system, age, race, and nutritional status (Angulo, 2005; Quiroz, 2011).

In Mexico, the economic impact of the presence of gastrointestinal nematodes in cattle has reached economic losses of up to $445.10 million (Reyes-Guerrero et al., 2021). In this sense, cattle farming in Chiapas develops in 83.4% of the territory, and considering that cattle is one of the animal species with the greatest susceptibility to gastrointestinal parasites, it is important to study parasitosis in this municipality because this disease could cause great economic losses (González & Santiz, 2010; CEIEG, 2018).

Currently, gastrointestinal parasitosis in cattle is one of the main animal health problems in the country. Therefore, it is necessary to carry out preventive medicine programs that control these conditions that have an impact on the productive efficiency of the livestock herd. Therefore, the collection of this information in the state is relevant, mainly in the municipality of Mapastepec, Chiapas, where livestock is the main socio-economic activity, so it is necessary to know the degree of infestation of these parasites in cattle.

Therefore, the objective of this study was to determine the prevalence and factors associated with gastrointestinal nematodosis in cattle in the municipality of Mapastepec, Chiapas.

MATERIALS AND METHODS

Research area

This research work was carried out in the municipality of Mapastepec, Chiapas, located in region IX, known as Isthmus-Coast, in southern Chiapas, Mexico. The total area of this municipality is 1,085.60 km2, with a warm and humid climate from January to September and semi-warm from October to December. Rainfall occurs in September and October with a monthly average of 450 mm. Its economic activity is based on extensive and intensive cattle farming; it exports cattle on a large scale, which generates important income for the municipality, among other activities (Cardoso-Vázquez et al., 2006; Becerra, 2009; INEGI, 2010).

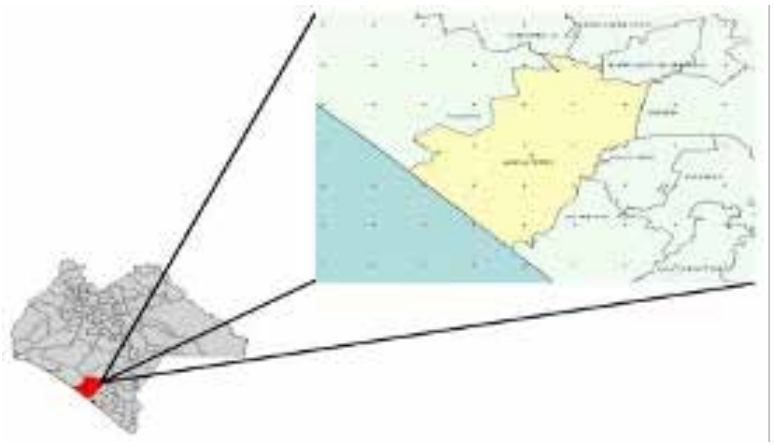

Figure 1. Localización geográfica del municipio de Mapastepec, Chiapas.
Source: Cardoso et al., 2006; GADM, 2018.

METHODOLOGY

This is a descriptive-cross-sectional research design that analyzes and describes the prevalence of gastrointestinal parasites, taking into account the variables: race, age, sex, and body condition.

A coprological sampling was carried out in the municipality of Mapastepec, Chiapas, taking into account the national livestock register, reported in 2021, which shows the existence of 2,290 livestock production units (UPP) with a livestock inventory of 158,330 head of cattle distributed in the different areas of this municipality.

For the determination of the samples, convenience sampling was used in 21 UPPs belonging to the Local Livestock Association of this municipality and cooperating producers. To carry out the determination of the finite sample size, the formula described by Aguilar (2005) was used.

$$n = \frac{N\,Z^2\,pq}{d^2\,(N-1) + Z^2\,pq}$$

n = sample size
N= 158,330 - population size
Z= 1.96 - confidence level
d= 0.05 - absolute accuracy level
p= 0.5 - proportion of the phenomenon under study in the population
q= 1 - p - proportion of the reference population that does not present the phenomenon under study

To obtain the sample size, a probability of occurrence of the phenomenon studied (p) of 50% was taken into account with a confidence level (Z) of 95% and absolute accuracy level (d) of 5% (Aguilar, 2005), resulting in 383 cattle. In this sense, due to the participation of cooperating producers, the number of samples was increased to 420 cattle from 21 UPPs. For this purpose, the number of animals that were sampled per ranch was 20 cattle, which it was divided into three age groups: young (35.7%), adult (24.8%), and old (39.5%).

Determination of prevalence

The Pinedo formula (2020) was taken as a reference to calculate the prevalence of gastrointestinal parasitosis.

$$P=\frac{\textit{Number of animals positive for gastrointestinal parasites}}{\textit{Total number of animals sampled}} \text{ X } 100$$

Inclusion criteria

- Age of cattle: young (0 to 12 months), adult (13 months to 24 months), and old (≥ 25 months)
- Body condition of cattle with scale 1.0 to 9.0. (1.0= very thin and 9.0= obese) This scale was taken into consideration as dual-purpose cattle (milk and meat) (Herd & Sprott, 1986)
- Health status (healthy)
- Cattle breed (all breeds)
- Sex of cattle (females and males)

Exclusion criteria:

- Freshly dewormed cattle
- Pregnant cattle
- Sick cattle

Elimination criteria

- Contaminated samples
- Loss of cold chain

Ethical and bioethical aspects in animal research:

During the development of this work, we took into account the considerations that mark the legislation and standards in the Law of Livestock Development and Sanitation for the State of Chiapas, the Official Mexican Standard NOM-062-ZOO-1999.

Interpretation of the results:

Morales et al. (2012) classify the degree of infestation of gastrointestinal parasites in large ruminants by Eggs Per Gram of Feces (HPGH):

- Mild infestation: 50-200 HPGH (+)
- Moderate infestation: >200-800 HPGH (++)
- High infestation: >800 HPGH (+++)

Statistical analysis

For the calculation of statistical significance, a 2x2 contingency table was used, using the Square Chi test ($P<0.05$). Simultaneously, the ratio of moments with a 95% confidence interval was calculated. Bivariate analysis was performed with the SPSS IBM Statistics version 25 software. (IBM Corp. © Copyright IBM Corporation 25.2017 version).

RESULTS

Prevalence of parasite infestation in the UPPs of Mapastepec, Chiapas.

Table 1 shows the prevalence results obtained concerning the determination of gastrointestinal nematodes, where 420 cattle were sampled, of which 262 animals (62%) were positive for gastrointestinal parasites and 158 (38%) animals were negative.

Table 1
Overall prevalence of gastrointestinal nematodes

Cases	Samples	Population	%
Positive	n	262	62
Negative	n	158	38
Sampled animals	n	420	100

Note: Own elaboration.

Of the gastrointestinal nematode positive cases by age group, 150 young animals were sampled, of which 70.7% (n=106) were bovine positive and 29.3% (n=44) were negative cases, while in the group of adult animals 104 animals were evaluated, resulting in 56.7% (n=59) of bovine positive and 43.3% (n=45) negative animals; finally, of 166 older animals 58.4% (n=97) were positive and 41.6% negative cases (n=69).

During this research, the classification of gastrointestinal nematodes was carried out in the 21 UPP evaluated, where the following genera were detected in 20 UPP: Trichostrongylus spp., Ostertagia spp., Cooperia spp., and Chabertia spp., with these four genera having the highest frequency (95.2%). The genus Haemonchus spp. was present in 19 UPP (90.5%), and the least frequent were the genera Strongylus spp. in 10 UPP (47.6%), and Trichuris spp. with six positive cases (28.6%).

According to the classification by age group, seven genera of parasites were detected in young cattle (Figure 2), of which the Cooperia spp genus represented the highest frequency (30.55%) and the Trichuris spp genus the lowest frequency (3.49%) of positive cases.

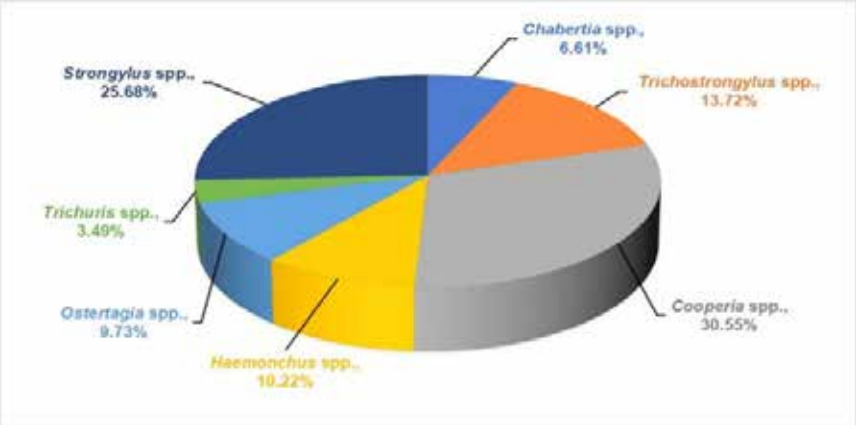

Figure 2. Gastrointestinal nematodes identified in young cattle

Figure 3 shows that the group of adult cattle presented infestations with the following genera: Cooperia spp (36%)., Trichostrongylus spp. (17%)., Strongylus spp. (15%)., Haemonchus spp. (13%)., Ostertagia spp. (10%)., Chabertia spp (7%), and the genus Trichuris spp (2%) were the ones with the lowest presence of positive cases.

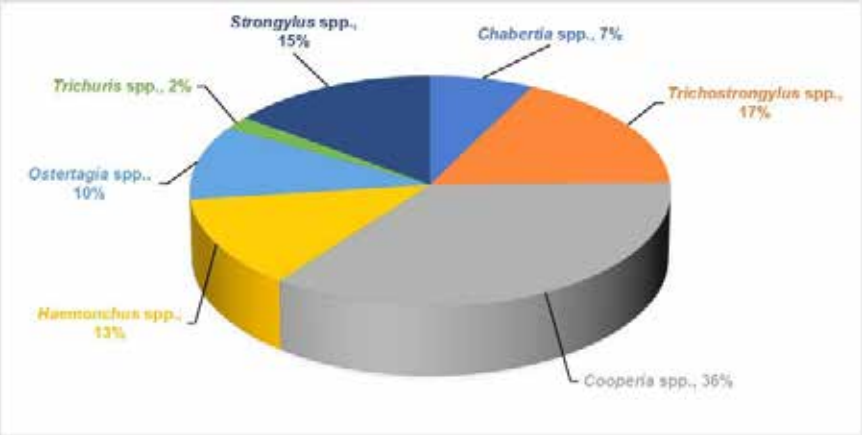

Figure 3. Gastrointestinal nematodes identified in adult cattle

With reference to old animals, the seven genera of nematodes above were identified. However, the genus Trichostrongylus spp. is the one with the highest presence, with 20.5%, in this population; on the other hand, the genus Trichuris spp. is the one with the lowest frequency, with 0.3% of positive cases (Figure 4).

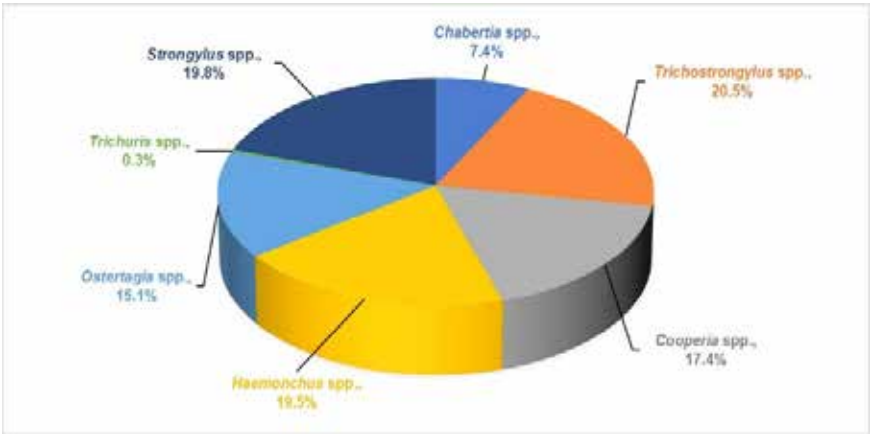

Figure 4. Gastrointestinal nematodes detected in old cattle

The results obtained according to the degree of infestation showed that young animals (378.3 ± 73.3 HPGH) and adults (219.5 ± 58.1 HPGH) presented a moderate degree of infestation, while old animals (153.6 ± 10.3 HPGH) presented mild cases. Therefore, the general average of the evaluated population manifested a moderate parasitosis of 250.50 ± 66.69 HPGH.

Regarding the sex of the animals, it was found that the 193 females evaluated showed a degree of mild infestation, while in the males, the infestation was moderate in 69 animals.

The overall result of positive animals was 262 for parasitosis. However, when classifying it by body condition of 1.0 (n=112), an infestation of 331.7 ± 72.9 HPGH was observed, while in the body condition of 3.0, there were 110 animals, both of which had a moderate infestation (212.3 ± 20.5 HPGH). In contrast, animals with a body condition of 5.0 (n=40) had a mild (182.5 ± 25.0 HPGH) presence of parasitosis.

As for the nine analyzed breeds of the sampled animals, the highest parasitic load was the Brahman breed (1950 HPGH) with an infestation considered as high; in contrast, the lowest parasitic load was the cross of Cebu x Cebu (62.5 HPGH) with an infestation considered as mild.

FACTORS ASSOCIATED WITH GASTROINTESTINAL PARASITOSIS IN CATTLE

In Table 2, the factors associated with the presence of gastrointestinal nematodes in cattle are mentioned. Regarding the Centro-Dulce location area of the municipality of Mapastepec, Chiapas, the genus Haemonchus spp reflected a value of 0.372 of Momios Ratio (RM), while in the Baja-Marítima area, the genus Ascaris spp showed a result of 0.454 RM ($P<0.01$). This represents a remarkable relationship in both variables with these gastrointestinal nematodes. On the other hand, the semi-intensive exploitation system detected the genus Ascaris spp, and in the extensive exploitation system, the genus Strongylus spp ($P<0.01$) with values of 0.375 RM and 0.305 RM, respectively.

Regarding the breed or cross, they manifested a significant association with the presence of parasitosis, reflected as follows: Cebu x Swiss with the presence of the genus Strongylus spp., (2.650 RM), and the Simbrah cattle breed had a relationship with the parasites Trichostrongylus spp (4.299 RM) and Trichuris spp (7.960 RM) ($P<0.01$). However, the cattle embedded between the Cebu x Cebu breeds presented the genus Cooperia spp (0.129 RM), ($P<0.01$). For its part, the Swiss American breed was associated with the nematode Strongylus spp with a value of 2.546 RM ($P<0.05$) and Ascaris spp of 21.500 RM ($P<0.01$). Finally, the Holando x Cebu cattle breed manifested the association with the nematode Haemonchus spp (1.864 RM) ($P<0.05$). Breeds such as Gyr, Guzerat, Brahman, and Black Sardinian did not show a significant association with gastrointestinal parasitosis ($P>0.05$).

Regarding the age of the animals, their relationship with the condition of parasitosis found that young cattle had the presence of the following more relevant genera, such as: Trichostrongylus spp (2.070 RM), Cooperia spp (2.179 RM), Chabertia spp (2.718 RM), Trichuris spp (5.743 RM) ($P<0.01$), and for Ascaris spp nematodes (0.232 RM), Haemonchus spp (1.644 RM) had lower values ($P<0.05$). The second age group was old animals, and a

relationship was found with the following genera: Cooperia spp (0.449 RM), Ascaris spp (7.706 RM) (P<0.01), and Trichuris spp (0.134 RM), Chabertia spp (0.508 RM) (P<0.05). In contrast, adult cattle had no relationship with the parasites detected (P>0.05).

Table 2

Factors associated with the presence of parasitosis in cattle

Factor	Genus	RM	LCI	LCS	*P Value*
Geographical area					
Centro – Dulce	**Haemonchus spp**	0.372	0.219	0.631	P<0.01
Baja – Marítima	**Ascaris spp**	0.454	0.408	0.505	P<0.01
Exploitation system					
Extensive	**Strongylus spp**	0.375	0.198	0.710	P<0.01
Semi-intensive	**Ascaris spp**	0.305	0.263	0.354	P<0.01
Breed or crossbreed					
CxS	**Strongylus spp**	2.650	1.577	4.454	P<0.01
HxC	**Haemonchus spp**	1.864	0.999	3.478	P<0.05
SI	**Trichostrongylus spp**	4.299	1.350	13.691	P<0.01
	Trichuris spp	7.960	1.540	41.149	P<0.01
SA	**Strongylus spp**	2.546	1.046	6.196	P<0.05
	Ascaris spp	21.500	7.333	63.036	P<0.01
CxC	**Cooperia spp**	0.129	0.017	0.974	P<0.01
Age					
Young	**Haemonchus spp**	1.644	1.002	2.696	P<0.05
		2.070	1.271	3.370	P<0.01
		2.179	1.407	3.374	P<0.01
		5.743	1.530	21.552	P<0.01
		2.718	1.514	4.882	P<0.01
		0.232	0.052	1.030	P<0.05
Old	**Cooperia spp**	0.449	0.281	0.717	P<0.01
	Trichuris spp	0.134	0.017	1.047	P<0.05
	Chabertia spp	0.508	0.266	0.968	P<0.05
	Ascaris spp	7.706	2.179	27.252	P<0.01

Note: P<0.01= Highly meaningful
P<0.05= Meaningful
CxS: Cebú x Suizo, HxC: Holland x Cebu, SI: Simbrah, SA: American Swiss, CxC: Cebu x Cebu, RM: odds ratio, LCI: lower confidence limit, LCS: upper confidence limit

Table 3 shows the results of parasitosis related to the animals' body condition. An association was found with the parasite Strongylus spp, with a value of 2.226 RM (P<0.01) in the body condition of 1.0, and in the same case for the body condition of 3.0, the genus Strongylus spp reflected a value of 0.549 RM (P<0.05). Therefore, cattle with a body condition scale of 5.0 had no significant relationship with the genera of the parasites (P>0.05). According to the sex variable, females were associated with the manifestation of the following genera: Cooperia spp had a value of 0.557 RM (P<0.01), likewise, the genera Ostertagia spp with a value of 0.519 RM, and Trichostrongylus spp with 0.542 RM (P<0.05). However, male cattle showed no association with parasitosis (P>0.05).

Concerning cattle living with backyard hens, the genus Ascaris spp had a value of 0.355 RM (P<0.01), and in the case of sheep, the parasites Strongylus spp and Chabertia spp had values of 0.827 RM and 3.174 RM, respectively (P<0.01). As for pigs, the following genera were identified: Ascaris spp (0.057 RM), Cooperia spp (0.121 RM), Ostertagia spp (0.124 RM), Trichostrongylus spp (0.194 RM) (P<0.01), and Chabertia spp (0.162 RM) (P<0.05).

Finally, the variable of food supplementation by grains (corn) and poultry manure both showed a relationship with the same genera Ascaris spp having a value of 0.206 RM (P<0.01), Haemonchus spp with 0.505 RM and Chabertia spp of 0.371 RM (P<0.05), continuing with the corn cane the nematode Chabertia spp (2.217 RM) was visualized (P<0.05) and in the corn silage the parasite Strongylus spp (0.110 RM) and Ascaris spp (13.500 RM) (P<0.01) were observed.

Table 3
Associated factors and presentation of positive cases of parasitosis in cattle

Factor	Genus	RM	LCI	LCS	*P Value*
Body condition					
1.0	**Strongylus spp**	2.226	1.336	3.710	P<0.01
3.0	**Strongylus spp**	0.549	0.324	0.929	P<0.05
Sexo					
Female	**Trichostrongylus spp**	0.542	0.323	0.911	P<0.05
	Ostertagia spp	0.519	0.297	0.909	P<0.05
	Cooperia spp	0.557	0.348	0.892	P<0.01
Animals in cohabitation					
Backyard hens	**Ascaris spp**	0.355	0.311	0.405	P<0.01
Sheep	**Strongylus spp**	0.827	0.788	0.868	P<0.01
	Chabertia spp	3.174	1.631	6.177	P<0.01
Swine	**Trichostrongylus spp**	0.194	0.046	0.822	P<0.01
	Ostertagia spp	0.124	0.017	0.921	P<0.01
	Cooperia spp	0.121	0.029	0.511	P<0.01
	Chabertia spp	0.162	0.022	1.203	P<0.05
	Ascaris spp	0.057	0.038	0.085	P<0.01
Food					
Corn	**Haemonchus spp**	0.505	0.261	0.978	P<0.05
	Chabertia spp	0.371	0.154	0.895	P<0.05
	Ascaris spp	0.206	0.170	0.249	P<0.01
Poultry manure	**Haemonchus spp**	0.505	0.261	0.978	P<0.05
	Chabertia spp	0.371	0.154	0.895	P<0.05
	Ascaris spp	0.206	0.170	0.249	P<0.01
Corn cane	**Chabertia spp**	2.217	0.990	4.963	P<0.05
Corn silage	**Strongylus spp**	0.110	0.015	0.812	P<0.01
	Ascaris spp	13.500	4.866	37.45	P<0.01

DISCUSSION AND CONCLUSION

In the present study, 62% of positive cases (n=262) were due to gastrointestinal nematodes, and 38% of negative cases (n=158) were found. This contrasts with the results of Marmolejo et al. (2023) in a study carried out in Villaflores, Chiapas, who sampled 384 cattle, of which they detected 33% positive for parasites and 67% negative for the presence of gastrointestinal nematodes. However, López and Sánchez (2009), who conducted a study of identification and prevalence of gastrointestinal nematodes in cattle from the municipality of Pijijiapan, Chiapas, with a population of 120 animals, detected 56.66% of positive cases (n=68) of gastrointestinal parasites. The

authors Marmolejo et al. (2023) and López and Sánchez (2009) have values lower than the positive cases of this study, with respect to the negative cases both values are higher than those of this research, probably attributed to the population of animals at the place of study, time of year (June), and the research's duration.

Regarding the degree of parasitosis by age group, in this study, it was found that 70.7% of young animals with positive cases of parasitosis (n=106) and 58.4% of old animals, possibly representing the age group most susceptible to this condition (n=97). These results contrast with those of the author Marmolejo et al. (2023), where they found results for young animals of 41.61% positive for gastrointestinal nematodes, and for old animals, 36.11% positive for parasitosis. For its part, Cruz's study (2009) reported a prevalence of gastrointestinal parasitosis in young cattle of 50% (n=21) and adult cattle of 16% (n=7) due to gastrointestinal nematodes. This study was conducted in the municipality of Raudales Malpaso, Chiapas. Both results show values below those found in the present study, possibly related to the size of the sample, time of year (June), and location of the study area.

In the research work, seven genera of gastrointestinal nematodes were identified; *Trichostrongylus* spp., *Ostertagia* spp., *Cooperia* spp., and *Chabertia* spp., being the ones with the highest presence, with 95.2% each, Haemonchus spp. was 90.5% and the ones with the lowest presence were *Strongylus* spp. (47.6%) and Trichuris (28.6%). On the other hand, Colina et al. (2013), who worked on the prevalence of gastrointestinal parasitosis in cattle in the Province of Chepén – Peru with a warm climate, identified *Oesophagostomum* spp (40.2%), *Cooperia* spp (32.8%), *Haemonchus* spp (28.1%), *Ostertagia* spp (26%), *Trichostrongylus* spp (24.3%), and *Trichuris* (1.8%). There is a coincidence of five nematode genera that have an impact on the productivity of bovine livestock.

In a study conducted by González and Santiz (2010) in Ocotepec, Chiapas, they found nine genera of gastrointestinal nematodes, coinciding with the genera: *Trichuris* spp., *Cooperia* spp., *Trichostrongylus* spp., *Chabertia* spp, and *Haemonchus* spp with this research. However, in this study, the parasite *Trichuris* spp has the most presence (60%) and *Chabertia* spp the least (0.77%).

There are differences between the studies presented, due to the variation in the population number of animals sampled, age, different geographical areas that are related to climatic conditions, time of year, and finally, an unnoticed preventive medicine protocol in each livestock production unit for the control of these endoparasites.

In this study, it was detected that we mostly worked with the following livestock crossbreeds: Cebu x Swiss (CxS), Holando x Cebu (HxC), Simbrah (SI), American Swiss (SA), and Cebu x Cebu (CxC), and the genera most

commonly found were: *Strongylus* spp., *Trichostrongylus* spp., *Trichuris* spp., *Ascaris* spp., *Cooperia* spp. (P<0.01) and *Haemonchus* spp. (P<0.05). In this sense, Pinedo (2020), when conducting research in which he compared the parasitic load between races: Girolando, Simmental x Holstein, and Brahman, where they only agreed with two genera of parasites: *Cooperia* spp and *Trichuris* spp, no association was detected between gender and breed of cattle (P>0.05). On the other hand, García et al. (2018), when studying the prevalence and risk factors associated with gastrointestinal parasites relating to parasitosis and cattle breeds such as Holstein and Normandy, the only coincidence was with the following genera: *Trichuris* spp., *Chabertia* spp (P>0.05), and *Ostertagia* spp (P<0.01). There is a relationship with gastrointestinal nematodes, except for breeds that differ with the study conducted, region, study population number, and environmental temperature.

The sex factor is one of the factors that represented an association with bovine females with the following genera: *Trichostrongylus* spp., *Ostertagia* spp (P<0.05), and with the genera *Cooperia* spp and *Ascaris* spp (P<0.01). In contrast, Cornejo (2019) and Lagos and Lascano (2021) did not find any significant relationship between this factor. This may be due to the number of animals sampled, in this case, more females than males.

According to the results obtained, in this research, the age variable found a relationship in young animals (0-12 months) with parasites: *Trichostrongylus* spp., *Cooperia* spp., *Trichuris* spp., *Chabertia* spp (P<0.01), and *Haemonchus* spp., *Ascaris* spp (P<0.05), while in old animals (≥ 25 months) the following genera were found: *Cooperia* spp., *Ascaris* spp (P<0.01), and *Trichuris* spp., *Chabertia* spp (P<0.05). Pinedo (2020) found a relationship with age in six groups of productive stages: bull, cow, heifer, turkey, beef, and calf, where they did find an association with age (P<0.002) and included the parasitic load of the genera found: *Eimeria* spp., *Monezia* sp., *Cooperia* sp., *Trichuris* sp., *Paramphistomidae*, and Protozoa.

In contrast, Armijos (2023) performed an age classification: calf, bull, heifer, and adult; however, they did not find an association with the identification of the following genera: *Eimeria* spp., *Haemonchus* spp., *Oesophagostomum* spp., *Cooperia* spp., *Moniezia benedeni*, and *Trichostrongylus* spp (P>0.05).

In the present research, we detected an association of some parasites with the age factor; similar results were found by Pinedo (2020), and coincide at the same time of year and the sampling of the animals. While Armijos (2023) differs with the results of these works because the diagnosis of parasitism was in temperate weather.

As for the farming system factor, it was classified as extensive with the *Strongylus* spp genus and semi-intensive with the *Ascaris* spp genus (P<0.01). Lagos and Lascano (2021) analyzed the extensive production

system, identifying the following genera: *Eimeria* spp., *Haemonchus contortus*, *Oesophagostomum* spp., *Ostertagia* spp., *Taenia* spp., *Trichuris* spp, and *Trichuris strongylus* spp, where they showed a relation with the farming system (P<0.01). Definitely, the farming system is a critical point in preventive medicine programs and, as a consequence, the health of the animals.

Ludeña (2023) in evaluating the comparison to extensive and intensive farming systems did not detect any association between the parasite loads of the genera *Entamoeba coli*, *Ancylostoma* spp., *Ascaris* spp., *Trichostrongylus* spp., *Lagochilascaris* spp., *Strongyloides* spp, and *Fasciola hepatica* in relation to farming system (P>0.05).

According to Lagos and Lascano (2021), there was only a relationship with the extensive system in the present research since both coincide with the warm-humid climate, although they do not have the same genera identified. While Ludeña (2023) did not observe any association between this factor, detecting only the genus *Ascaris* spp, although they do not belong to the same cattle exploitation system.

Regarding the factor of cohabiting animals, an association with cases of parasites was found with backyard chickens with the parasite *Ascaris* spp (P<0.01), sheep with the genera *Strongylus* spp and *Chabertia* spp (P< 0.01), and swine with the parasites *Trichostrongylus* spp., *Ostertagia* spp., *Cooperia* spp., *Ascaris* spp (P<0.01), and *Chabertia* spp (P<0.05). As opposed to Cornejo (2019) and Armijos (2023), who mention that there is no relationship to the presence of gastrointestinal parasites. Perhaps the differences between the two studies were that in the present research, there is a close interrelationship in the animals' pens, water, feed, and common spaces in the production units.

REFERENCES

Aguilar, B. S. (2005). *Fórmulas para el cálculo de la muestra en investigaciones de salud*. https://www.redalyc.org/pdf/487/48711206.pdf

Angulo, F. J. (2005). *Nematodosis Gastrointestinales. En manual: Manual de Ganadería Doble Propósito*. https://www.researchgate.net/profile/Judith-Petit-Aldana/publication/329197437_Manual_de_ganaderia_doble_proposito-_Capitulo_11/links/5bfc6ad5a6fdcc76e722aafd/Manual-de-ganaderia-doble-proposito-Capitulo-11.pdf

Armijos, P. Y. (2023). *Determinación de la presencia de parásitos gastrointestinales en bovinos en la parroquia San Antonio de Cumbe del cantón Saraguro*. https://dspace.unl.edu.ec/jspui/bitstream/123456789/26650/3/YessicaMarisol_ArmijosPineda..pdf

Becerra, A. (2009). *Estado Soconusco*. http://estadosoconusco.blogspot.com/2009/01/mapastepec.html

Cardoso-Vázquez, E. A., Torres Ramírez, M., Díaz Jerónimo, R., Ávila Ramos, F. J., y Gutiérrez Popoca, J. C. (2006). *Proyecto de estudios de peligros naturales en municipios de la planicie costera del estado de Chiapas*. https://www.ceieg.chiapas.gob.mx/productos/files/RPRYPCHIS/PELIGROS_MAPASTEPEC.pdf

CEIEG, C. E. (2018). *La ganadería en los terrenos rurales de Chiapas.* https://www.ceieg.chiapas.gob.mx/productos/files/SPAF/La_ganaderia_en_los_terrenos_rurales_en_Chiapas.pdf

Colina, J. C., Mendoza, G. A., y Jara, C. A. (2013). *Prevalencia e intensidad del parasitismo gastrointestinal por nematodos en bovinos, Bos taurus, del Distrito Pacanga (La Libertad, Perú).* https://revistas.unitru.edu.pe/index.php/facccbiol/article/view/559/522

Cornejo, S. D. (2019). *Factores epidemiológicos asociados a la prevalencia de parásitos gastrointestinales en bovinos (Bos taurus) de la raza Holstein, en los meses de agosto – noviembre del 2018 en el distrito de Polobaya Provincia de Arequipa.* https://repositorio.unsa.edu.pe/server/api/core/bitstreams/cbd7d502-a9d8-4bc9-af4b-a867f7735af4/content

Cruz, V. L. (2009). *Prevalencia, cuantificación e identificación de géneros parasitarios en bovinos de doble propósito en proceso de transición orgánica en Raudales Malpaso municipio de Tecpatán, Chiapas.*

GADM. (2018). *Mapastepec is a municipio (municipality) of Chiapas, México*. https://gadm.org/maps/MEX/chiapas/mapastepec.html#google_vignette

García, C. D., Díaz Anaya, A. M., y Pulido Medellín, M. O. (2018). *Prevalencia y factores de riesgo asociados a la presencia de parásitos gastrointestinales en bovinos del municipio de Ventaquemada (Boyacá)*. http://infometrica.org/index.php/syh/article/view/16/13

González, P. C., y Santiz Sánchez , R. (2010). *Prevalencia de nematodos gastroentéricos en bovinos de la Asociación Ganadera Local*

del Municipio de Ocotepec, Chiapas. https://drive.google.com/file/d/1V_GuWy2ePY1JWWkFgW4OZqfpL3c8bsNZ/view

Herd, D. B., y Sprott , L. R. (1986). *Body Condition, Nutrition and Reproduction of Beef Cows*. https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/199640/nutrition_body_condition_nutrition.pdf?sequence=1&isAllowed=y

INEGI. (2010). *Compendio de información geográfica municipal 2010 Mapastepec, Chiapas.* https://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/07/07051.pdf

Lagos, M. G., y Lascano Rivera, S. E. (2021). *Prevalencia de parásitos gastrointestinales en bovinos de 12 a 36 meses de edad en la parroquia La Belleza, Cantón Francisco de Orellana*. http://dspace.espoch.edu.ec/bitstream/123456789/16275/1/17T01690.pdf

López, C. J., y Sánchez Reyes, R. C. (2009). *Identificación y prevalencia de nematodos gastrointestinales en ganado bovino del Rancho "Santa Rosa" municipio de Pijijiapan, Chiapas.*

Ludeña, A. M. (2023). *Prevalencia y factores de riesgo de helmintos gastrointestinales en ganado bovinos de tres comunidades del distrito de San Pablo - provincia de Ramón Castilla - Loreto - 2022*. https://repositorio.unapiquitos.edu.pe/bitstream/handle/20.500.12737/9257/Milagros_Tesis_Titulo_2023.pdf?sequence=1&isAllowed=y

Marmolejo, B. E., Meza Rodríguez, L. A., Ramírez Barrios, H., León Velasco, H., y Maza Santiago, C. (2023). *Determinación de nematodos gastrointestinales en el ganado bovino del municipio de Villaflores, Chiapas - México*. https://spaunach.mx/wp-publicaciones/RevistaUNyCONo.3nov.23.pdf

Morales, G., Pino, L. A., Sandoval, E., Jiménez, D., y Morales, J. (2012). *Relación entre la condición corporal y el nivel de infestación parasitaria en bovinos a pastoreo como criterio para el tratamiento antihelmíntico selectivo*. http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1609-91172012000100010

Pinedo, A. C. (2020). *Prevalencia de parásitos gastrointestinales en bovinos del distrito de Jepelacio, provincia de Moyobamba, región de San Martín - 2019*. https://repositorio.unsm.edu.pe/bitstream/11458/4214/1/MED.%20VETERINARIA%20-%20Charlin%20Eduardo%20Pinedo%20Amacifu%C3%A9n.pdf

Quiroz, R. H. (2011). *Epidemiología y control de nematodos gastrointestinales en bovino con énfasis en México*. https://www.gob.mx/cms/uploads/attachment/file/848424/8381_T_1_S_1_-_Epidemiologia_de_enfermedades_parasitarias-compressed.pdf

Reyes-Guerrero, D. E., Olmedo Juárez, A., y Mendoza de Gives, P. (2021). *Control y prevención de nematodosis en pequeños rumiantes: antecedentes, retos y perspectivas en México*. Https://cienciaspecuarias.inifap.gob.mx/index.php/Pecuarias/article/download/5840/4587.

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Social psychology to understand the challenges of educational inclusion

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— Abstract—

Educational inclusion represents a challenge for all educational institutions, since despite the fact that important changes have been generated in both educational models and educational policies, exclusion problems still persist. The objective of this article is to present a general overview of what the exercise of educational inclusion implies from the perspective of social psychology to promote reflection on the actions of all those involved in school spaces. The analysis from social psychology on stereotypes, prejudices, and attitudes can help understand the complexity of the discriminatory and exclusive responses of those who fail to understand diversity and therefore respect the condition of each person. Collaboration and dialogue can be elements in favor of advancing in this task of learning from and with differences.

Keywords:

Inclusion; prejudices; stereotypes; attitudes; challenges .

Social inequalities exist in our society. The conditions that generate them must be recognized in a specific analysis to identify the challenges that must be faced in this situation and that lead minority groups to experience discrimination, risk of exclusion, violence, among others, which do not favor equity and therefore inclusion.

The state of Chiapas is characterized by a wide cultural richness, but also with serious deficiencies with respect to the rest of the country, inequality can be expressed for example by not speaking the same dominant language that in this case is Spanish, being a woman, being a child, having a sexual preference and orientation different from that of the majority, being of African descent, being an elderly person, living in extreme poverty or having a disability condition, since there is a risk of being excluded from actively participating in society, in education and even in important family or community decisions.

This risk of being excluded undermines what has been established at the international level from the Sustainable Development Goals proposed by the United Nations (UN) because it fails to eradicate everything that allows people to live in a more just and equitable society. In particular, with regard to Goal 10 "Reduction of inequalities", an interesting fact is that "one in six people in the world has suffered some type of discrimination, disproportionately affecting women and people with disabilities" (p. 32), which represents a challenge for all nations, but in particular for those where discrimination against these minority groups is still part of everyday life. Despite this slogan, both nationally and globally, we find many cases of extreme poverty, displaced or damaged people who cannot claim their rights or seek to survive, leaving aside the opportunity to receive an education in schools.

To avoid the risk of exclusion, it is necessary to propose or give continuity to a series of strategies of diverse nature to minimize the disadvantages of the condition in which these people find themselves, in a climate of collaboration, so that everyone has a place. One of the subjects that will be highlighted in this article is educational, since it is imperative to generate changes in training, in how to feel and think about others. This is important since in our societies it is common that hierarchies of excellence are privileged (Perrenoud, 1995) by measuring people only for some of their qualities without a holistic vision in terms of competitiveness.

Therefore, this article exposes educational inclusion and what can be done to break down the barriers that generate these unequal conditions and make sure education is for all. Firstly, a brief history of inclusive education is presented to understand the importance of its origin from the Education for All policy, secondly, the concept of educational inclusion will be addressed, thirdly, the factors that may interfere for inclusion to occur will be analyzed

from a psychological perspective and finally some ideas will be presented to contribute to a favorable climate that avoids the risk of exclusion.

EDUCATION FOR ALL, IN SEARCH OF EQUITY

To understand the importance of inclusion, it is necessary to refer to the concerns that were expressed at the meetings of UN member countries in 1990, carried out by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which as the body in charge of evaluating and proposing the main changes in education at the international level, identified the need to discuss strategies to make education for all a reality and not a simple aspiration.

This year, the World Conference on Education for All and the Framework for Action to Meet Basic Learning Needs was held in the city of Thailand, specifically in Jomtien, which expressed the need to design strategies so that by 2030 the problems encountered regarding the number of people who still did not have access to education, a fundamental right for all people regardless of sex, age or condition, were eradicated. The diagnosis that led to this proposal indicated that:

> More than 100 million boys and girls, of whom at least 60 are girls, do not have access to primary education. Over 960 million adults – two-thirds of them are illiterate, and functional illiteracy is a problem in all countries, both industrialized and developing. More than a third of adults lack access to print knowledge and to new skills and technologies that could improve the quality of their lives and help them shape and adapt to social and cultural changes. More than 100 million children and countless adults fail to complete the basic education cycle, and there are millions who, even by completing it, fail to acquire essential knowledge and skills (UNESCO, 1990, p. 1).

As a brief summary, this conference highlighted the importance of providing primary education in addition to eradicating illiteracy. In the same document, this body (UNESCO, 1990) stated that "education can contribute to a safer, healthier, more prosperous and environmentally amiable world" (p. 6). Therefore, emphasis is placed on the social function of education by fostering social, economic, and cultural progress, while promoting tolerance and cooperation at the international level. It is through education that it was hoped to suppress discrimination against minority groups, such as children in the street, the poor, migrants, refugees, or displaced people, as well as people with disabilities.

In three decades, more international conventions have been held, such as those in *Dakar* in 2000, *Incheon* in 2015, and the United Kingdom in 2019,

which were expected to meet the Millennium Development Goals and the current Sustainable Development Goals. The latter with a call to the private sector to meet the proposed goals, but what was suggested in 1990 has not yet been achieved. While there has been important progress, there are still great challenges to making equity in education a reality. As the achievements at each meeting are reviewed, the factors involved in the results are identified, proposing specific strategies and programs, such as the inclusive education proposal, in which it is proposed to eradicate the barriers that limit educational changes.

In the case of Mexico, in the data found in the census carried out by the National Institute of Statistics and Geography (INEGI) (2020), by educational level regarding the percentage enrolled, 49.3% of students were enrolled in basic education, 24.0% in upper secondary education, and 21.6% in higher education. However, they also point out that 4.9% were out of school, and 0.2% unspecified. This is to point out some figures related to school access in our country. Likewise, it was reported that out of a total of 126,014,024 inhabitants, 7,168,178 have some type of disability (INEGI, 2021).

On the other hand, the National Council for the Prevention of Discrimination (CONAPRED) recognizes different discriminated groups, such as women, children, young people, the elderly, indigenous peoples, persons and peoples of African descent, persons with disabilities, persons of sexual and gender diversity, domestic workers, migrants and refugees, persons with HIV, day laborers and agricultural workers, as well as for their precarious economic condition. The discrimination to which they are subjected can range from hindering access to public education to the prohibition of freely choosing their employment, as well as wage differences, among others.

This discrimination may be part of "an everyday practice that consists of giving unfavorable treatment or undeserved contempt to a certain person or group" (CONAPRED, 2024, parr. 1). It is highlighted that the effects on the people who suffer from it have a negative character with an impact on dignity with consequences that in extreme cases can lead to loss of life. From this perspective, it is important to consider the search for alternatives to improve coexistence with equity.

INCLUSION AND EQUITY IN EDUCATION

Equity is a serious issue, since not all people are in the best social, political, and economic conditions, and this will significantly affect the results that are measured not only at the national level but also at the international level. Access to education and health, social security, or housing services is not the same for everyone, which will influence educational outcomes. In a review carried out by UNESCO, it considers that in terms of gender parity

(equality between men and women) there has been significant progress, although it recognizes that there are still gaps, that is, inequality between those who live in rural and urban areas or in those spaces in which they continue to be subjected by patriarchal practices.

From the point of view of Santiago, Tremblay & Arnal (2008, as cited in Toscano, Ponce, Cruz, Zapién, Contreras & Pérez, 2017), to talk about equity it is important to take into account two dimensions; the first related to the review of personal circumstances so that they are not an obstacle to the educational potential they may have and the second, ensuring access to quality education regardless of people's conditions.

Derived from the above, it is necessary to see how a condition related to access to services in an unequal way becomes a limitation for some people to enter the education system. It should be remembered, for example, that in our country, there are regions with extreme poverty where education may not be a priority, as survival would be. Such is the case of the extreme poverty data measured by the National Council for the Evaluation of Social Development Policy (CONEVAL, 2023), in which they indicate that there was a decrease of 0.5% going from 38.3% in the second quarter of 2022 to 37.8% in the second quarter of 2023. However, this organization recognizes that still 9.1 million Mexicans are in this condition, bringing as consequences, among others, the problems of educational lag.

Because there are areas in our country with higher poverty rates, there are also some geographical regions with high economic development, showing the situation of inequality that is experienced on a daily basis, especially in the southern region, including Chiapas, Guerrero, and Oaxaca. This may explain the results of UNESCO's measurement of reading competence, finding that our country is at a proficient level with 63% compared to Ireland, which has 98%. Although progress has been made in this aspect, many indicators are not at all flattering and show the great problems that must be addressed for the achievement of equity.

Educational inclusion emerges as an alternative in favor of equity, providing, from the point of view of UNESCO (2009), proposals adjusted to the needs and conditions of people to promote access, permanence, and graduation from the educational system, taking advantage of all possible opportunities.

Talking about inclusion is thinking about the global change of the entire educational system, both in nature and in the culture and identity of people. In this sense, it is pertinent to think that the impact must reach the configuration of the curricula in attention to diversity and the recognition of what is culturally specific to all people. Thus, for example, Valenzuela, Guillén-Lugigo, Campa, and Sánchez (2020) recognize that "the introduction of indigenous knowledge in higher education for many years has been positioned as a problem of equity or social justice as a study on indigenous

peoples in unquestioned colonial disciplinary spaces " (p. 26). Therefore, the discussion about what and how to promote inclusion is broad and complex because of all the implications in a culture characterized by individualism and little solidarity with others.

To understand inclusion, it is important to address what exclusion is. This phenomenon, which has many causes, is understood as opposed to inclusion, since, while one side integrates, the other excludes (Jiménez, 2008). So, under this idea, exclusion is a substantial part of inclusion, that is, they are two sides of the same coin, which happen in processes of interaction. It is included so as not to exclude, or when excluded, you want inclusion to exist. Exclusion happens in all groups; it is only important to pay attention to what is happening around us and to realize the hidden ways in which violence is sometimes exercised by excluding others.

THE ISSUE WITH DISCRIMINATION AND THE RIGHT TO EDUCATION

Educational systems in general and schools in particular have been guided by the hierarchies of excellence, measuring and placing people according to the demonstration of what they have learned, as proposed by Perrenoud (1995) when he talks about the construction of school success and failure, recognizing that even when people have exercised their right to education they can also abandon it if they have problems of failure and academic lag. From the point of view of Díaz Barriga (2023):

> The qualification was developed as an instrument that allows students to be classified, assigned a school place, but also socially, an instrument of social discrimination through which the future of each subject is decided in some way: to obtain a qualification to survive in the school system or to be expelled from it. Qualification is a need of the education system. This means that through measuring what is known, some may not continue in educational spaces or remain in them while being discriminated against (p. 110).

School learning has been shown to depend on many factors, which are presented differently in urban and rural environments, or those living on the periphery of cities. Working children who arrive at schools, the children of migrants who partially leave school to harvest together with their family, are characteristic examples that conditions are not the same for everyone, and that this can influence their academic performance. These may have few or poorly developed skills to understand educational content. Poor vocabulary or reading habits can trigger problems not only in reading competence and comprehension but also serious problems in academic performance; hence, it is interesting to reflect on how the condition of each person in the classroom

differently affects what they learn and how they learn it. However, the measurement does not include these personal characteristics, and therefore, they may end up leaving school with the idea of "I am useless", explained from the helplessness learned since the proposal of the concept by Seligman (1960, as cited in Galindo & Ardila, 2012).

In addition to the above, in some cases it is inevitable to observe the attitudes of the rest of these students' classmates, the least who offer help, and the majority who may prefer that the "bad students" withdraw to have less school competence and continue to maintain the status of "best student". With this, it is shown that, although inequality is a strong problem that is related to the economic structure of a country or a region, in the end, it is perceived in the classroom through the interactions that are established between both students and teachers. The latter is when you have the firm belief that "not everyone should reach the goal, only the best".

A disadvantaged group with the right to education is people with disabilities, who are allowed to stay in regular schools, that is, with everyone else. Some time ago, there were special education schools that helped them, but it did not benefit them because they were considered "special" and it was better that they were distanced from the rest of the people. Although it sounds difficult, deep down, when these people started entering regular schools, there were and are people who still think that "special children" should stay in special schools. The above is due to ignorance or misconceptions about the characteristics of people with a certain disability. These people show resistance to accepting coexistence in the same classroom and school space between the "normal" and the "special".

Attitudes of rejection, mockery, and discrimination persist, even leading to overt or covert violence, disguised as good intentions by the community in which people find themselves. In particular, the analysis of negative attitudes to inclusion in teaching staff shows through the research carried out that the common denominator is rejection attitudes, with the argument of not being sufficiently prepared to teach them (Paz-Maldonado & Flores Girón, 2021; Sisto, Pérez-Fuentes, Gázquez-Linares & Molero-Jurado, 2021).

To address this set of problems Both and Ainscow (2002) proposed more than two decades ago the *Index* for *Inclusion* which was published by UNESCO in an effort to promote the dissemination of this model in which inclusion will involve first of all the review of the relationships, values and beliefs that exist in schools to generate changes to the school culture. Secondly, they suggest a thorough analysis of the policies that may be generating exclusion, and thirdly, reflect as a collective, practices that are also considered as obstacles that do not favor the integral development of all people in school premises, regardless of their condition.

In 2018, the Mexican Ministry of Public Education (SEP) published a book called Key Learning Techniques for Comprehensive Education. Strategy for equity and entry into basic education: for students with disabilities, outstanding abilities, and severe learning difficulties. This document discusses the concept of inclusive education, focusing on guidelines on inclusive practices and how to work with a document called the *Index* for *Inclusion*, which proposes a diagnosis of the school and then generates specific strategies for inclusion. At the international level, this document is based on the Universal Declaration of Human Rights, the Convention on the Rights of the Child, the Convention on the Rights of Persons with Disabilities, and the 2030 Global Agenda for Sustainable Development. While inclusive education is thought to be associated with disability, this paper mentions that it is not unique to the care of this group of people. The important thing is to "foster educational communities where diversity is valued and appreciated as the prevailing condition" (Sep, 2018, p. 14).

Likewise, it proposed the Universal Learning Design (ULD) with emphasis on the design of didactic strategies so that people with wide differences in their abilities could achieve their educational objectives, because, in the classrooms, people have multiple forms of representation, action, and expression, as well as motivation.

Recently, the SEP (2024) in its Model of the New Mexican School (NEM) recognizes inclusion as an articulating axis from its curricular organization, because:

> The state is obliged to guarantee this right from the initial level to the higher level, especially monitoring the students from indigenous peoples, Afrodescendants, migrants, women, people with disabilities, and marginalized sectors of the country, have the conditions to exercise their right to education at all levels and modalities (p. 15).

Unfortunately, this is for basic education. The question is, what are the guidelines for secondary education and higher education? Unfortunately, few students reach these educational levels because they were very likely made to feel that they had no capacity to move forward, being carried away by opinions based on negative prejudices.

Toscano, Ponce, Cruz, Zapién, Contreras and Pérez, (2017), point out that in the case of Higher Education Institutions (HEIs) they have difficulties in integrating the procedures to address the diversity of what they call vulnerable groups and although "they are allowed to enter the university, but they do not achieve permanence or graduation" (p. 44), among other things due to infrastructure problems, thus offering a deficit education in which policies, plans, processes and techniques for quality care must be improved.

The inclusion of people with disabilities at the higher level was the object of study of Pérez-Castro (2016) who analyzes the problem, realizing that some of the main HEIs strategies have been in a) institutional regulations and policies, b) in academic and economic support, c) in physical and information accessibility and d) in other measures and services, although it recognizes that an educational policy is not yet consolidated, due to the unsystematic nature of the information generated to know what the impact is.

An interesting exercise regarding the inclusion of university students from indigenous peoples is the model proposed from the ICT of Valenzuela and collaborators (2020) who, from a descriptive-correlational study to a sample of 86 students from the University of Sonora, Mexico, found that the use that students make of ICT facilitates inclusion with the guidance of teachers is necessary for its correct use academically and to have greater communication in didactic terms. Likewise, an important relationship was found between inclusive policies and practices from the model proposed by Ainscow and Both (2000), allowing the former to promote an inclusive culture with the use of mobile devices, fostering inclusion.

PREJUDICES, STEREOTYPES, AND ATTITUDES IN EDUCATIONAL INCLUSION. BREAKING DOWN BARRIERS

Being part of an inclusive culture must be common in all groups of people, since it is a natural process and is expressed in the forms of communication and interaction; inclusion has been institutionalized in most countries, so that governments have worked hard to ensure that schools have protocols and contents in textbooks that allow an inclusive, democratic and participatory coexistence.

This, in turn, has generated research to understand and identify the problems in the process of incorporation into educational spaces, as well as the design of proposals to make this possible. A task that is clearly titanic in some cases, when unpleasant experiences of exclusion are known, because it seems that violence persists in various forms and manifests itself in almost all spaces of coexistence, particularly in school spaces, where relationships are very important for school success.

An approach to the origin of the problems of exclusion, discrimination, and violence for being different can be found in the concept of stereotype from social psychology, which according to Allport (2000) cited in Gómez & Espinosa (2021) refers to a negative attitude towards something or someone based on a series of overgeneralized beliefs, but at the same time erroneous (given the nature of the belief) that gives rise to discriminatory behaviors. On the other hand, in the case of prejudice, it allows the justification of these behaviors and can be expressed openly or covertly, even reaching

rejection, all based on a comparison of superiority, putting the other in the place of inferiority. An example is the perception of threat studied by Gómez and Espinosa (2021) to understand its role as a mediator between migrant Venezuelans, from the perspective of Peruvians.

The complexity of both concepts studied in social psychology clarifies the expressions of actions of some people against others, from a series of misconceptions that are shared by the majority about a minority. One may be experiencing exclusion or discrimination by moving away from people by labeling people with negative attributes, based on the impression of some stereotype or prejudice, altering coexistence, and even generating overt or covert violence towards this particular person or group of people. Because excluding implies an act of violence.

The various prejudices about a person or group can unleash attitudes and behaviors that exclude either because of some physical or mental disability, sexual orientation, social and economic class, religion or socio-cultural context of origin, for example, a prejudice based on a stereotype can lead to attitudes of racism by not interacting or doing so as little as possible with people with Afro-descendant traits (due to their black skin color and curly hair), because historically from the position of "whites", they are untrustworthy people. Another example of prejudice based on stereotypes is of a student declared homosexual for considering her "masculine" (some call them "tomboy"), so that her peers will treat her rudely, she can be excluded from some meetings, believing she does not fit in with the rest of the girls.

Cardona (2023) carried out the analysis on gender stereotypes and their relationship with employment, identifying that:

> Gender gaps exist from the beginning of professional careers, given the expectations that society establishes about the life trajectories of people, men, and women. But it increases when those expectations are met and women are placed in female-oriented careers, such as caring for their family or other dependents (p.693).

The above examples are situations that happen on a daily basis in schools, causing effects on students, and, although it may seem surprising, the exclusion is so subtle and invisible that often teachers and authorities fail to distinguish them from everyday behaviors and are justified as normal. It may be that the teacher himself, without manifesting it or having full awareness, may be sharing a prejudice, which needs to be recognized in order to act in a different way, especially by generating inclusive processes in the classrooms. Now, how is it that excluding others is normalized? The answer can be found by analyzing prejudices, as a psychosocial phenomenon, which is part of our reality, since it helps us to gather a series of negative characteristics

about a person or object and thus avoid a danger created under our experience; on the other hand, the stereotype as a set of generalized ideas helps to order the experience we have about the context and then the attitude appears conceived as the way we act or react to an event, person or situation, regularly in a negative way.

These phenomena must be raised when talking about inclusion, since they all have a cultural root, that is, what has been learned at home or from a very young age will influence our interaction with others. Surely a lot of people have wondered: why do we have a negative opinion towards people with tattoos? Or why do we believe that women should study socially oriented careers and not engineering? As well as this, there are prejudices and stereotypes of which we have a pre-established attitude. The conflict is when they are confronted with other ideas that can unbalance the cultural mindset and put us in check, but isn't that the sense of unlearning that damages others?

WHAT CAN BE DONE FOR INCLUSION?

There are many alternatives to promote inclusion. Reflection on what is apparently "normal" can be the first step to intervene; the other is dialogue, not imposing ideas but establishing communication with others by accepting their way of thinking and having their own opinions. Through dialogue and confrontation, the ideas and experiences of others are communicated and discussed, and how what happens to others and their environment is perceived, which are the main concerns, doubts, ideas, and proposals about someone or something in particular. Therefore, as members of a group, it must be ensured that everyone has an equal opportunity to speak, to dialogue, and to resolve conflicts through democratic and participatory coexistence.

Another tool that works, but from the teacher's perspective, is to promote participation. It is a perfect formula: inclusion is achieved only and exclusively through participation. Although it seems like a simple class exercise, achieving the genuine participation of everyone implies having a closer idea of who the students are, giving the opportunity for everyone to express themselves, respecting points of view, recognizing the possibilities of developing creativity to learn, which allows us to identify that, while being different, our world is expanded. It is no longer just a personal vision but the shared vision in which others offer new ways to understand our reality.

Likewise, it is important to become aware of civic responsibility towards others, that is, that being members of society implies understanding that the "other" also has rights and an interpretation of reality that is different from their own. This is crucial because inclusion requires the ability to

recognize others and understand the diversity of beliefs and personalities. With this, we must bear in mind that all people are free to say what they think. However, if what is said is lacerating the other person in any way, it means that there is a prejudice or attitude that is being counterproductive in the interaction towards those who maintain that attitude. Therefore, it is relevant to question stereotypes, prejudices, and attitudes about other people.

It is recognized that one of the main barriers to inclusion in school has to do with the resistance to changing the way in which the school is perceived, the function it has, and that it should not be only for a few but for all. From this idea, it is necessary to take into account that exclusion is also a cultural pattern, that is, that society also excludes. With this, the fragmentation in which the various groups live can be analyzed based on political, economic, and social conditions. The work of educating for inclusion has to break barriers and promote equity.

Each person can do many things in favor of inclusion, first at the personal level, since to the extent that people change their way of seeing others, this will allow them to generate changes at the institutional level. The school should no longer be selective, and its idea of learning should be more open, creating scenarios to learn from everyone, from their differences. It has been taught that to be successful, it is necessary to think and be equal to others, and that being different is bad. "You have to deliver the tasks all in the same format", "whoever finds a shortcut in a mathematical problem is cheating". These are the phrases that make us assume that being different is not good. However, the difference allows us to approach a view of the world that is not our own and broadens our perspective.

On the other hand, this old belief that disability is a disease or a punishment must be eradicated; it is a condition, and from there, you can live well. Some people are short, and that can't be changed; that's an example of a condition. Others are born with a skin color that will not be modified either; that is another condition. Being born with Down syndrome is a condition, and you can live with it as with the color of your skin. Therefore, it is important to respect the condition of each human being and contribute as much as possible to avoid exclusion.

It is also important to remember that poverty leads people to make decisions that can cause little attachment to school, hindering motivation to overcome. It is not the absolute responsibility of the person to have been born in a context of vulnerability. They work hard every day to get ahead and deserve respect. In general, everybody, regardless of their status, must be respected.

In schools, while they regularly teach competing to be better than others, that doesn't make them better people. If it happens when you are sensitive to other people's problems or conditions, when you have the ability to put yourself in the shoes of the other. That's called empathy, so one of the core

values that should be cultivated in classrooms is to be empathetic. Everyone deserves a chance, and we can all learn from each other. Our differences and those of others must be learning opportunities; it must be what complements us, rather than what divides us.

Finally, inclusion is greatly enhanced by diversity; this variety of beliefs, thoughts, tastes, inclinations, and desires makes collaborative work richer. It is possible to imagine that all people are equal on the basis of their differences, which implies uniqueness. Understanding that there is a diversity of experiences commits our identity to a dynamic of solidarity and growth, in which we can learn from others, get involved in their topics of interest, as well as teach the group what we know. Thus, in our classroom, even in our family, we must provoke inclusion by recognizing the great diversity, but, above all, by learning to be responsible and respectful of others.

Something to keep in mind is that due to technological advances, access to information can allow both teachers and students to obtain reliable knowledge to rethink old beliefs and stereotypes that have been regularly discriminated against. A good digital and informative competence can become a strong ally in learning communities and favor a culture of inclusion.

REFERENCES

Both, T. & Ainscow, M. (2000) *Índice de inclusión. Desarrollando el aprendizaje y la participación en las escuelas*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000138159

Cardona, B. (2023). Los estereotipos de género en el empleo una cuestión de actualidad. *Cuadernos Electrónicos de Filosofía del Derecho. No, 49. 1-8*. DOI: 10.7203/CFED.49.26459.

CONAPRED (2024) ¿Qué es la discriminación? https://www.conapred.org.mx/discriminacion-en-mexico/que-es-la-discriminacion/

CONEVAL (2023). Comunicado de prensa No. 8. https://www.coneval.org.mx/SalaPrensa/Comunicadosprensa/Documents/2023/Comunicado_08_ITLP_2TRIM_2023.pdf

Díaz-Barriga, A. (2023). ¿Calificar o evaluar? Dos procesos que se confunden y pervierten el acto educativo. *Revista Iberoamericana de. Educación. Superior. No. 40*, VOL. XIV. 99-115. DOI: https://doi.org/10.22201/iisue.20072872e.2023.40.1547

Galindo, O. &. Ardila, R. (2012). Psicología y pobreza. Papel del locus de control, la autoeficacia y la indefensión aprendida. *Revista de Psicología Latinoamericana. Vol.30*, No. 2. 381-407. http://www.scielo.org.co/pdf/apl/v30n2/v30n2a13.pdf

Gómez. M. & Espinosa, A. (2021). Percepción de amenaza como mediadora de la relación entre el prejuicio hacia los migrantes venezolanos en Perú. *Liberabit. 27* (1). 1-20. DOI: https://doi.org/10.24265/liberabit.2021.v27n1.04

INEGI (2021). Estadísticas a propósito del día internacional de las personas con discapacidad. https://www.inegi.org.mx/contenidos/saladeprensa/aproposito/2021/EAP_PersDiscap21.pdf

INEGI (2024). Características educativas de la población. https://www.inegi.org.mx/temas/educacion/

Jiménez, M. (2008) Aproximación teórica de la exclusión social: complejidad e imprecisión del término. Consecuencias para el ámbito educativo. *Estudios pedagógicos. XXXIV*, No. 1. 173-186. https://www.scielo.cl/pdf/estped/v34n1/art10.pdf

Organización de las Naciones Unidas (2023). Informe de los Objetivos de Desarrollo Sostenible. Edición especial. https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023_Spanish.pdf?_gl=1*o5uriv*_ga*MzAzOTM4NzIuMTcxMjU4NTY1Mg..*_ga_TK9BQL5X7Z*MTcxMjU4NTY1Mi4xLjEuMTcxMjU4NTc0Ni4wLjAuMA..

Paz-Maldonado, E. y Flores-Girón, H. (2021). Actitud del profesorado universitario hacia la inclusión educativa: una revisión sistemática. *Rev. Bras.Ed. Esp. Bauru. V.27*. 1037-1052. https://doi.org/10.1590/1980-54702021v27e0008.

Perrenoud, Ph. (1995). *La construcción del éxito y el fracaso escolar*. Morata

SEP (2018). Aprendizajes clave para la educación integral. Estrategia de equidad e inclusión en la educación básica: para alumnos con discapacidad, aptitudes sobresalientes y dificultades severas de aprendizaje, conducta o comunicación. https://maestrias.clavijero.edu.mx/cursos/MCDEMS/T4/410EI/modulo2/documentos/SEP_2018._Estrategia_de_Equidad-e-Inclusion.pdf

SEP (2024). La Nueva Escuela Mexicana: principios y orientaciones pedagógicas. https://dfa.edomex.gob.mx/sites/dfa.edomex.gob.mx/files/files/NEM%20principios%20y%20orientacio%C3%ADn%20pedago%C3%ADgica.pdf

Sisto, M., Pérez-Fuentes, M. C., Gázquez-Linares, J. J. & Molero-Jurado, M. M. (2021). Actitudes hacia la inclusión educativa de alumnos con discapacidad: variables relativas al profesorado y a la organización escolar en Educación Primaria. *Revista Electrónica Interuniversitaria de Formación del Profesorado. 24* (1), 221-237. DOI: https://doi.org/10.6018/reifop.397841

Toscano, B., Ponce, J., Cruz, A., Zapién, A., Contreras, G. y Pérez (2017). Análisis de la inclusión en la Educación Superior en México. Una propuesta de indicadores para los Organismos Acreditadores. *Tecnología Educativa Revista CONAIC. Vol. 4*, núm. 2. 35-51.

UNESCO (1990) Conferencia Mundial sobre educación para todos. https://unesdoc.unesco.org/ark:/48223/pf0000085625_spa

UNESCO (2017). Guía para asegurar la inclusión y la equidad en la educación. https://unesdoc.unesco.org/ark:/48223/pf0000259592

Valenzuela, B., Guillén-Lugico, M., Campa, R. y Sánchez, C. (2020). Modelo inclusivo por medio de las TIC en atención a estudiantes de grupos étnicos. *PSICUMEX. Vol. 10*, No. 1. 21-38. DOI: 10.36793/psicumex.v10i1.334

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Smart Cities and the Implementation of Artificial Intelligence in Autonomous Transportation – A Proposal for the City of Querétaro

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— Abstract—

Smart cities, powered by the use of artificial intelligence (AI), represent an innovative approach to addressing contemporary urban challenges and improving the residents' quality of life. These cities use advanced technologies and data analysis to optimize resource management, public services, mobility, and decision-making. This article compares different aspects of urban life, such as autonomous transportation, application of renewable energy, use of the Internet and level of foreign direct investments in the cities of Tokyo, Singapore and Querétaro to finally give a proposal for the implementation of autonomous buses in the city of Querétaro, using the good practices applied in Tokyo and Singapore.

Keywords:

Smart cities; IoT; autonomous transportation.

Due to the rapid growth of population density in urban cities, infrastructure and services are required to meet the needs of city residents. On this basis, there is a significant increase in digital devices, such as sensors, actuators, and smartphones, that drive huge business potential for IoT (Internet of Things), as all devices can interconnect and communicate with each other on the Internet. The IoT prototype is composed of smart, self-adjustable objects that are connected to each other through a global network infrastructure. The IoT is mostly considered as real objects, widely dispersed, with low storage and processing capacity, with the aim of improving the reliability, performance, and security of the smart city and its infrastructures.

The Internet of Things is an infrastructure that includes physical devices, modern vehicles, buildings, and even essential electrical devices that we use constantly, interconnected with each other over the Internet so that they can accumulate and exchange data with each other. These "Things" have priority and the ability to self-organize and communicate with other things without human intervention. The IoT concept aims to present an even more ubiquitous and immersive Internet. In addition, by allowing easy access and interaction with a wide variety of devices, such as appliances, monitoring, surveillance cameras, sensors, displays, actuators, and vehicles. The IoT will improve the development of various applications that take advantage of the enormous amount and diversity of data produced by objects to implement more services to companies, citizens, and public administrations (Yang, Han, Wang, Jiang, Song, 2020).

Increasingly, organizations in various industries are using IoT to operate more efficiently, provide better customer service, improve decision making, and increase business value. With IoT, data can be transferred over a network without the need for person-to-person or person-to-computer interactions. An IoT ecosystem consists of web-enabled smart devices that use embedded systems (such as processors, sensors, and communication hardware) to collect, send, and act on the data they acquire from their environments. IoT can also use artificial intelligence and machine learning to help make data collection processes easier and more dynamic.

IoT allows machines to complete tedious tasks without human intervention. Companies can automate processes, reduce labor costs, reduce waste, and improve service delivery. IoT helps make it less expensive to manufacture and deliver goods and provides transparency into customer transactions. IoT is one of the most important technologies and continues to advance as more companies realize the potential of connected devices to stay competitive (Gillis, 2023).

IoT offers several benefits to organizations. Some benefits are industry-specific, and others are applicable across multiple industries. Common benefits for businesses include the following:

- Oversees general business processes.
- Improve Customer Experience
- Save time and money.
- Improves employee productivity.
- Provides integration and adaptive business models.
- Enables better business decisions.
- Generate more revenue.

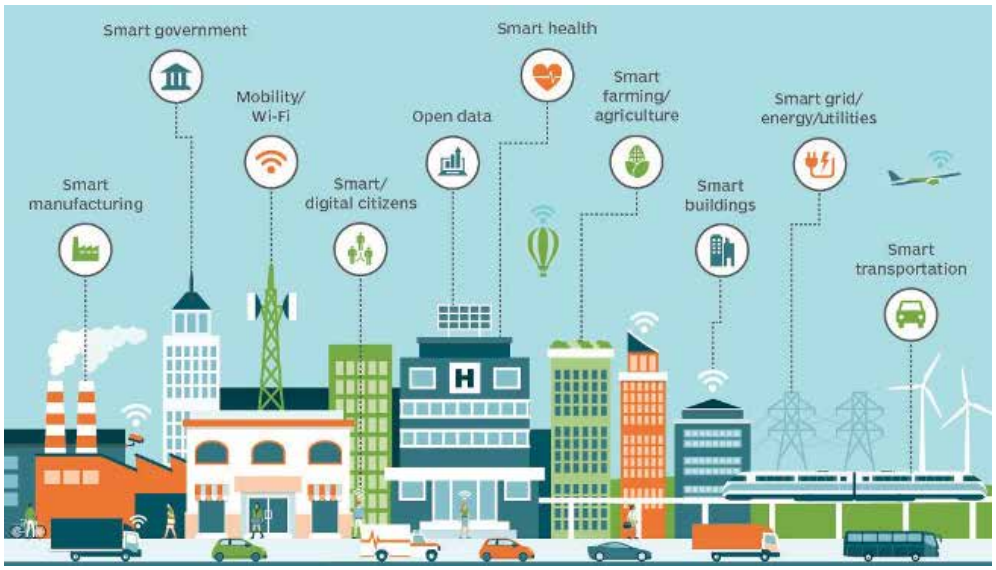
There are numerous real-world applications of the Internet of Things, ranging from consumer IoT and enterprise IoT to manufacturing IoT. IoT applications span numerous verticals, including automotive, telecommunications, and energy. In the consumer segment, for example, smart homes equipped with smart thermostats, smart appliances, and connected electronics, lighting, and heating devices can be controlled remotely via computers and smartphones (Evans, 2011).

IoT can be implemented very well in the concept of smart cities.

A smart city is a municipality that uses information and communication technologies (ICTs) to increase operational efficiency, share information with the public, and improve both the quality of government services and the well-being of citizens. The overall mission of a smart city is to optimize city functions and drive economic growth while improving the quality of life for its citizens using smart technology and data analytics. The smart city is given value based on what they choose to do with the technology, not just how much technology they may have. Several important characteristics are used to determine the intelligence of a city. Some of these characteristics are:

- An infrastructure based on technology
- environmental initiatives :
- a high-performance public transport system
- a safe sense of urban planning and
- to live and work within the city and use its resources

The success of a smart city depends on its ability to form a strong relationship between the government and the private sector. This relationship is necessary because most of the work that goes into creating and maintaining a data-driven digital environment occurs outside of government (Rodriguez & Lopez, 2018).



Note. Adapted from https://www.techtarget.com, 2023.

Figure 1. Components of a Smart City

Smart cities use a combination of Internet of Things (IoT) devices, software solutions, user interfaces (UIs), and communication networks. However, they rely primarily on the IoT. IoT devices sometimes have processing capabilities called edge computing. Perimeter computing ensures that only the most important and relevant information is communicated through the communication network. A firewall security system is also necessary for the protection, monitoring, and control of network traffic within a computer system (Rodriguez & Lopez, 2018).

Conservation and energy efficiency are important parts of smart cities. Smart cities use their network of connected IoT devices and other technologies to achieve their goals of improving the quality of life and achieving economic growth. Successful smart cities follow four steps:

1. Collection: Smart sensors throughout the city collect data in real time.
2. Analysis: The data collected by the smart sensors is evaluated to extract meaningful information.
3. Communication: The knowledge found in the analysis phase is communicated to decision-makers through strong communication networks.
4. Action: cities use insights gleaned from data to create solutions, optimize operations and asset management, and improve residents' quality of life.

Sustainability is another important facet of smart cities. Urbanization is expected to increase further in the coming years. According to a United

Nations report, about 55% of the world's population now resides in an urban area or city. This figure is expected to increase by 68% in the coming decades. Smart technology will help cities sustain growth and improve efficiency for the well-being of citizens and governmental efficiency in urban areas in the coming years. While cities already have environmental advantages, such as smaller geographic footprints that impact fewer ecological systems, they also negatively impact the environment with emissions, such as their extreme use of fossil fuels.

Many cities around the world have begun to implement smart technologies, and some stand out as the most advanced in development. Such as the following cities: Kansas City, Missouri, USA; San Diego, California, USA; New York, New York, USA; Toronto, Canada; Singapore, Tokyo, Japan; and many more (Smith, 2020).

Most new smart city projects are concentrated in the Middle East and China, but in 2018, Reykjavik and Toronto were listed alongside Tokyo and Singapore as some of the smartest cities in the world. The city-state of Singapore, often considered the gold standard of smart cities, uses IoT-enabled sensors and cameras to monitor the cleanliness of public spaces, the density of crowds, and the movement of locally registered vehicles. Its smart technologies help businesses and residents monitor energy use, waste production, and water use in real time. Singapore is also testing autonomous vehicles, including full-size robotic buses, as well as a senior tracking system to ensure the health and well-being of its senior citizens (García & Pérez, 2019).

METHOD

The methodology used in this article is qualitative and quantitative statistical analysis, providing and guaranteeing both safety and accuracy to the research results. This article makes use of a statistical graph of progressive growth for the representation of the percentage of different indicators. The graphs presented are comparative statistics and show the quantitative data of the advancement of technology in smart cities, making a comparison between Querétaro, Singapore, and Tokyo. The statistical data collected are from secondary sources, using as sources government institutions and the statistical institutes of the aforementioned countries to collect the data necessary for the creation of the graphs. Descriptive statistics are used in the quantitative methodology part to analyze the sources and the data obtained.

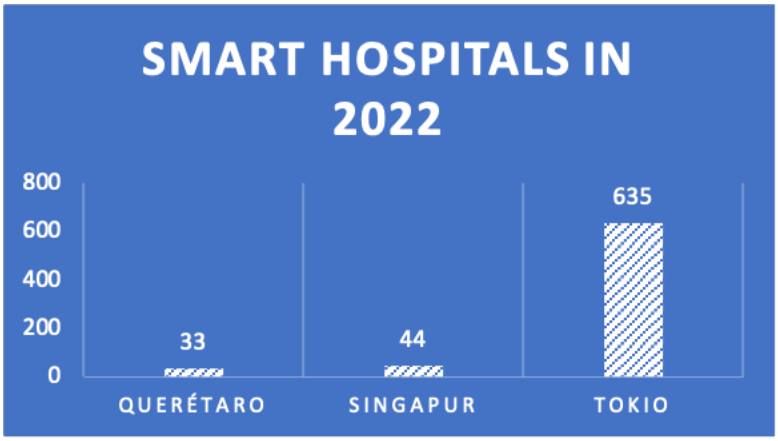
RESULTS

In Singapore and Tokyo, being two developed smart cities, an artificial intelligence system has been implemented in many aspects of public welfare. However,

Querétaro also has several advances in the areas of transportation, renewable energies, and penetration of international capital through foreign companies.

Table 1
Smart hospitals in 2022

Querétaro	Singapur	Tokio
33	44	635



Note. Own elaboration.

In the first table, we observe the differences in the health sector. In Querétaro, it has recently been one of the sectors that has had the most development, especially private hospitals that are constantly growing. Currently, the city has 25 private hospitals with artificial intelligence and 8 public hospitals. In Singapore, there are 16 public hospitals, 8 private hospitals, and 20 public polyclinics. In Tokyo, the number of these health centers is significantly higher, 635 in total.

Tabla 2

Uso de Energía renovable en % para 2022

Querétaro	Singapur	Tokio
15	1	13.7

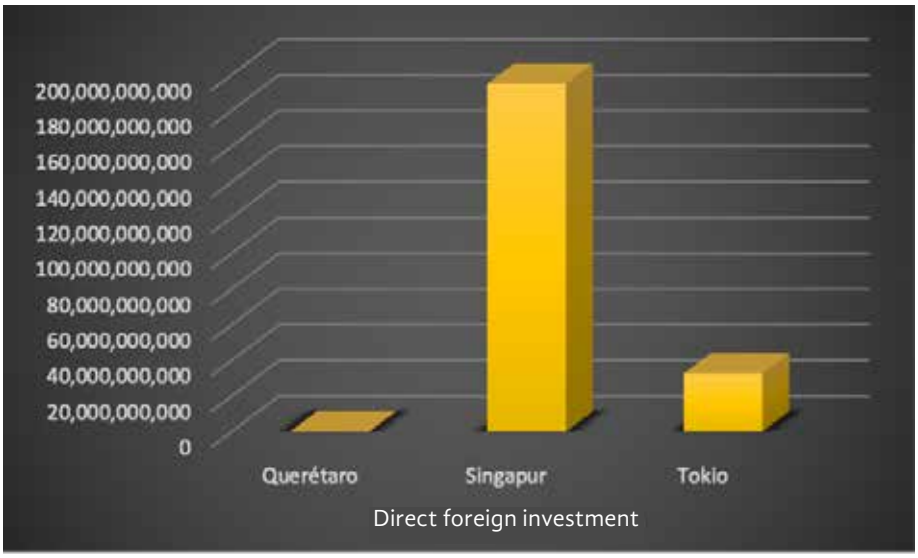
Note. Own elaboration.

Table No.2 evaluates the use of renewable energy in the three cities. Querétaro is the city where different renewable energies, such as wind, hydro, and biomass, have been implemented the most. Singapore, for lack of natural resources, hardly uses green energy, and Tokyo has many government policies that promote the use of this type of energy.

Table 3

Foreign direct investment in 2022, amount in USD

Querétaro	Singapur	Tokio
380,000,000	195,000,000,000	32,530,000,000

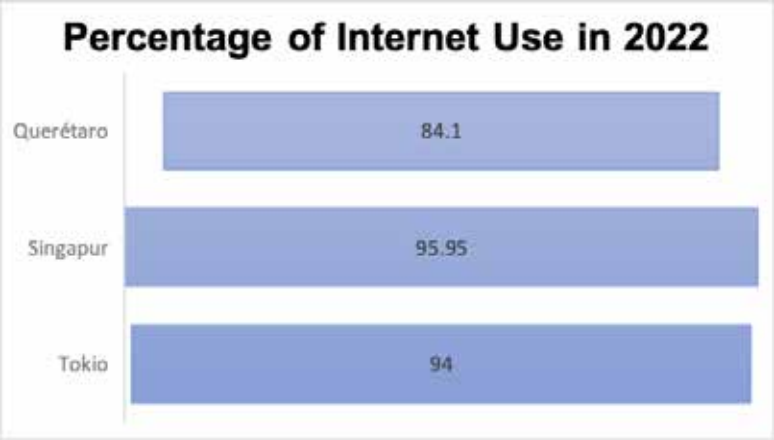


Note. Own elaboration.

The third table shows the different foreign investments through international companies in the three cities. Singapore is the leader in this indicator, and Querétaro, although every year more international companies of different branches open in the city, still does not reach high levels of foreign capital.

Table 4
Internet usage in % by 2022

Querétaro	Singapur	Tokio
84.1	95.95	94



Note. Own elaboration.

In the last table, No.4, we observe the difference in the use of the internet and smart devices in the three cities. Tokyo and Singapore have almost similar levels, with almost total reach of the population, using new technologies. Querétaro has also made great progress in this indicator, reaching 84% by the end of 2022.

All these data show the advancement of technology in the different areas of the societies studied - transportation, investments, health, etc., which allows rapid progress towards making Tokyo and Singapore, in this case, increasingly smarter cities. Querétaro is also following in their footsteps by implementing more and more tools appropriate to a smart city. For such purposes, the authors give a project proposal for autonomous buses that could be incorporated into the city of Queretaro and thus increase the use of intelligent technology and artificial intelligence.

DISCUSSION AND CONCLUSION

Proposal for an autonomous bus project in the city of Queretaro

With the information on the application of artificial intelligence and its use in different aspects of human life in smart cities, it can be demonstrated that it has great advantages for the growth and development of cities today. One of these aspects is also in the area of transportation, where more and more autonomous vehicles are helping to improve traffic flow in cities and

prevent accidents. An example of this is the use of autonomous transportation. In France, the city of Lille introduced the autonomous metro in the 1980s. Today, there are also autonomous buses in France, Scotland, Spain, and many other countries. In the European Union, since 2022, there are laws that require public transport to have artificial intelligence to protect pedestrians. Artificial intelligence opportunities in transportation also include logistics optimization through real-time and historical data, vehicle maintenance prediction, supply chain optimization, and route planning with traffic prediction and real-time updates.

Tools to implement:

- The Blind Spot Detection (BSD) system is a solution oriented to large vehicles, whose field of vision may be more limited. It detects pedestrians, cyclists, and other moving objects in real time, within the vehicle's reduced visibility zones, through image processing with advanced artificial intelligence. When the person or object moves within the vehicle's safety zone, the system sends a visual and acoustic signal to the driver, alerting them to the presence of an object in the blind spot.
- The Driver Status Monitor (DSM) has a large number of applications. Artificial intelligence detects distractions on the part of the driver, for example, if someone is smoking, using the phone, or showing signs of drowsiness. This solution, in addition to monitoring and recording distraction signals, alerts the driver to the incident by activating an acoustic and light alarm. These incidents are recorded on a server for later evaluation.
- The Azimuth 360 system works with a series of cameras placed around the vehicle. Each of these cameras collects a large amount of information that is transmitted to the driver in near real time, giving him or her a peripheral view of what is happening around the vehicle. The system is a great help when driving in the dark (thanks to its night vision), greatly facilitates maneuvering, and helps to avoid collisions.
- Use of a tool capable of storing and managing all the information generated by these security systems. When an incident occurs, it is important to have an analysis of where, when, and under what circumstances the event occurs. The Azimut BusBrain management platform allows you to visualize, in real time, each of the vehicles in the fleet, see its location, know how fast it is traveling, know what is happening inside and outside the vehicle, as well as the incidents that have occurred in that vehicle.

In this article, the authors make the proposal to create a network of autonomous buses that, through artificial intelligence, would cause an improvement in the circulation of vehicles in the State of Queretaro. Part of the artificial intelligence to be implemented in the buses of Queretaro would be the Azimut 360 system, that puts cameras around the vehicle collecting information in real time. The proposal itself consists of creating autonomous transportation routes that run along the busiest avenues of the city, which are Avenida 5 de Febrero and part of the Historic Center of the city, to reach the bus terminal at the other end. The line would be complementary to the existing public transportation system and would use an exclusive lane for better accident prevention. The proposal would be made to the municipality of Querétaro to make the autonomous bus part of its fleet. Based on calculations made from the beginning of the implementation of autonomous buses in Tokyo and Singapore, and adjusted to the city of Queretaro, traffic would decrease by 10-15% thanks to the use of the route, and would prevent at least 10% of road accidents involving pedestrians.

Smart cities have been a great achievement of mankind that has helped improve human life in many parts of the world, thanks to artificial intelligence. Several areas of the cities and the life of each individual have changed a lot with its implementation. In conclusion, Artificial Intelligence is playing an increasingly important role in transportation, driving optimization, efficiency, and profitability in logistics operations. From route optimization and fleet management to real-time tracking and improved safety, AI offers innovative solutions to transportation challenges. The other areas mentioned in this article, such as renewable energy, internet usage, and international business, have also been greatly improved by the use of artificial intelligence, turning cities into *Smart cities* in more and more places around the world. Artificial intelligence has its advantages, but also has clear disadvantages of its use, such as job displacement, privacy and security issues, and technological dependence. However, it has been proven that its increased use in human life has greatly improved it compared to past decades and is expected to continue to increase opportunities for development and welfare in the coming years.

REFERENCES

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. En *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 3848-3855). IEEE.

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. Routledge.

D. El-Baz and J. Bourgeois. (2015). Smart cities in Europe and the alma logistics project. ZTE Commun., vol. 13, no. 4, pp. 10–15.

D. Evans. (2011). The Internet of Things: How the Next Evolution of the Internet Is Changing Everything. [Online]. Available: http://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL. pdf

García, A., & Pérez, M. (2019). Desarrollo de infraestructuras en ciudades inteligentes. *Revista de Urbanismo, 15*(2), 45-60.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. (2007). Smart cities: Ranking of European medium-sized cities. Final Report.

Gillis, A. S. (2023). Internet of things (IoT). IoT Agenda. https://www.techtarget.com/iotagenda/definition/Internet-of-Things-IoT

H. V. K. K. M. T. e. a. O. Vermesan, M. Harrison. (2009). The Internet of Things - Strategic Research Roadmap. *Cluster of European Research Projects on the Internet of Things.*

Instituto de Ciudades Inteligentes. (2021). *Informe sobre Tendencias Actuales en Ciudades Inteligentes*. Instituto de Investigación Urbana.

J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions," Future Gener. *Comput. Syst., vol. 29*, pp. 1645–1660.

J. Yang, Y. Han, Y. Wang, B. Jiang, Z. Lv, H. Song. (2020). Optimization of real-time traffic network assignment based on IoT data using DBN and clustering model in smart city. *Future Generation Computer Systems*. 108 976 – 986.

L. U. Khan, I. Yaqoob, N. H. Tran, S. M. A. Kazmi, T. N. Dang, C. S. Hong. (2020). Edge-computing-enabled smart cities: A comprehensive survey, *IEEE Internet of Things Journal 7* (10) 10200–10232.

N. C. Luong et al. (2016). Data collection and wireless communication in the Internet of Things (IoT) using economic analysis and pricing models: A survey. *IEEE Commun. Surveys Tuts., vol. 18*, no. 4, pp. 2546–2590.

Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. *The Information Society, 27*(4), 281-293. https://doi.org/10.1080/01972243.2011.583819

R. Petrolo, V. Loscrì, and N. Mitton. (2017). Towards a smart city based on a cloud of things, a survey on the smart city vision and paradigms. Trans. Emerg. *Telecommun. Technol., vol. 28*, no. 1, Art. No. e2931.

Rodríguez, L., & López, P. (2018). Tecnologías emergentes en el diseño de ciudades inteligentes. En *Congreso Internacional de Urbanismo Sostenible* (pp. 120-135). Universidad XYZ.

Smith, J. (2020). *Ciudades Inteligentes: Conceptos y Desarrollo*. Editorial ABC.

V. Fernandez-Anez. (2016). Stakeholders Approach to Smart Cities: A Survey on Smart City Definitions. *Cham, Switzerland: Springer*, pp. 157–167. [Online]. Available: http://dx.doi.org/ 10.1007/978-3-319-39595-1_16.

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Evaluation of the physical and mechanical properties of artisanal clay brick manufactured in the metropolitan area of Tuxtla Gutiérrez

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— Abstract—

The objective of this work was to evaluate the geometric characteristics and strength of handmade clay bricks manufactured in the metropolitan region of Tuxtla Gutiérrez, Chiapas, in accordance with current standards. Forty bricks from six different suppliers were selected to analyze geometric variation, water absorption percentage, volumetric weight, and compression strength. The tests were conducted following the NTCM-20 and NMX–C–ONNCCE regulations. The results show that while the length and width dimensions of the bricks meet the recommended minimum values, the height does not. 50% of the analyzed samples exceeded the maximum water absorption limit of 23%. All samples surpassed the minimum volumetric weight of 1300 kg/m^3. Compression tests indicated an average strength of 23.41 kg/cm^2, representing only 33.44% of the minimum compression strength of 70 kg/cm^2 set by the standards. These results highlight the need to regulate the production of fired clay bricks in the region, to ensure compliance with normative standards and to design masonry walls that are compatible with local materials.

Keywords:

Mud brick; water absorption; compression strength; masonry.

Annealed Mud Brick (AMB) is a basic masonry material in the construction of homes in Mexico. It has been used since the time of the colony, although its massive use for construction in popular housing emerged at the beginning of the 20th century. Currently, the AMB in the national environment is one of the most used in the construction of masonry walls; in Tuxtla Gutiérrez, it is the second most used material for the construction of walls in popular housing (Argüello Méndez et al, 2022).

However, the AMB pieces manufactured in the metropolitan area of Tuxtla Gutiérrez have been used without reliable knowledge of their physical and mechanical properties, since they are not standardized or evaluated in a laboratory, and these properties are of interest for the calculation of masonry structures. Knowing the real characteristics of this material makes it possible to properly design the dimensions of masonry walls and improve their performance. Guaranteeing a building with a better structural response to different types of stresses, especially in regions of great seismic activity.

The manufacturing procedures of the AMB in the region are mainly artisanal, cooked in wood-fired ovens, and industrialized, cooked in industrial ovens. The pieces have a prismatic shape with different proportions in their dimensions. Commonly, the dimensions of the most used pieces are 5 cm high, 10 cm wide, and 19 cm long, not counting the masonry joint.

The use of AMB has certain advantages: it is a material that can be used in load-bearing walls and partition walls, adapting to many architectural styles. It can contribute to energy savings in buildings due to the thermal insulation properties it can possess. Depending on its quality and the minimum protection provided during its useful life, it can reach approximately 100 years. Brick parts are more economical (less than $10.00/piece and require little maintenance) than other similar masonry materials. It can be considered a "sustainable" and "friendly to the environment and living beings" material, since it does not contain pollutants and allergens. These characteristics make AMB a timeless material, since in Mexico and Chiapas its use represents an identity and part of the local culture.

AMB could be considered a material of natural origin and environmentally friendly manufacturing. Its manufacture requires minimal industrial treatments, reducing and being more efficient in the polluting intermediate processes, since the ecological and carbon footprint could be reduced. In this sense, the AMB becomes a suitable option for the construction of low-income housing.

Most of the experimental studies on masonry worldwide have focused on the study of the physical and mechanical properties of this material. In Mexico, Professor Meli (1975) investigated the seismic behavior of masonry walls, analyzing the variability of the component materials, the determination of basic properties of masonry in small specimen tests, and the study of behavior under lateral loads in one direction and under alternating loads.

Their results contributed significantly to the development of recommendations for the design of masonry structures in Mexico. Since then, controlled tests have been carried out in different parts of the world to determine the physical and mechanical properties of this material.

Piscal Arévalo et al. (2012) evaluated the mechanical properties of solid ceramic bricks manufactured by hand in the municipality of Ocaña (Colombia). First, the physical characterization of the clay used as raw material was carried out, then different brick producers were selected, and non-destructive and destructive tests were carried out for quality control. For this purpose, they used the Colombian Technical Standard NTC-4017, "Methods for sampling and testing of masonry units and other clay products". They were able to determine the modulus of elasticity and compressive strength of the tested material.

In El Salvador, Berríos Alvarado and Gómez Bonilla (2015) studied the compressive strength of mud brick piles using two types of mortar. In addition, they evaluated the characteristics of the stress-strain relationship in these masonry piles. They concluded that the use of different mortars does not produce significant changes in masonry quality. They also determined that the values of the modulus of elasticity of this material are lower than those indicated by the Salvadoran standard “Technical standard for the design and structural construction of masonry".

Soto and Sanchez (2017) investigated the main physical and mechanical properties of handmade mud brick produced in northwestern Honduras. They analyzed the geometric dimensions, absorption percentage, and compressive strength of individual pieces. They compared their results with ASTM C 62 standards, concluding that the material meets the minimum required strength. In addition, depending on the moisture absorption capacity of the tested bricks, they may be suitable for use in high-humidity environments. Evaluation of the geometric dimensions revealed that the material has a uniform geometry.

In 2016, Aguilera Morán carried out an extensive study on the characterization of the physical and mechanical properties of the annealed mud brick of the city of Aguascalientes and its conurbation area. He gathered material from 38 different brick kilns with batches of 7 pieces. He tested 71.5 % of the total number of pieces and left 28.5 % as a reserve. He mentions that the geometric characterization and compressive strength tests on brick pieces were carried out per the standards of the National Organization for Standardization and Certification of Construction and Building (ONNCCE). The analysis of the results shows that 61% of the lots tested do not meet the minimum compressive strength criteria indicated in the NMX-C-404-ONNCCE-2012 standard. In addition, none of the 190 pieces studied

complies with the geometric dimensions established by the NMX-C-038-ONNCCE-2013 and NMX-C-404-ONNCCE-2012 standards.

On the other hand, Arbildo Huamani and Rojas Paco (2017) studied the resistance to axial and diagonal compression in masonry specimens of mud bricks, manufactured in Tacna, Peru. In their work, they considered a mortar joint thickness of 1 cm and a cement-sand dosage of 1:4. They carried out controlled compression tests on 5 piles and 5 walls, according to the protocol indicated in the NTE 070 regulations of Peru. They concluded that the material analyzed has medium strength and durability, suitable for general-purpose masonry constructions. However, the type of brick studied should not be used for buildings in particularly rigorous service conditions. In addition, they suggest carrying out strict quality control and inspection of this material during the construction process of the building.

Other studies have focused on determining the shear strength of mud brick masonry. Among these studies, the one carried out by Valdivia Espinoza (2020) stands out, who determined the resistance to compression and shear in the masonry of industrially manufactured mud bricks in Huánuco, Peru. The tests were carried out following the protocols of the N.T.P. 399.605 and E.070 regulations of Peru. Based on his results, he concluded that it is not advisable to use this brick in the construction of load-bearing walls because its compressive strength values are lower than those indicated by the regulations, tending to shear the walls under the action of diagonal tension.

In Chiapas, despite the wide and attractive use of this material, there is a lack of sufficient studies on the geometric and mechanical characterization of locally manufactured LBR. This prevents making sensible calculations for the design of structures with this type of masonry and obtaining adequate levels of structural safety. On the other hand, there are also no regional construction regulations for the design of structures with this construction system. The current construction regulations for Tuxtla Gutiérrez do not include a section in which the design of masonry buildings is addressed or the quality of the used masonry elements is recommended.

Due to the absence of specific regulations in Chiapas, in the metropolitan region of Tuxtla Gutiérrez, there is no regulation of the LBR quality produced by manufacturers. As a consequence, there is no uniformity in the manufacture of this material, with the parts being of dubious and poor quality. This puts structures and their occupants at risk in cases of seismic stress.

MATERIALS AND EXPERIMENTAL PROGRAM

6 AMB suppliers were chosen, and from each, a batch of 40 pieces was purchased, using a total of 30 pieces for tests such as geometric characterization, initial water absorption, and simple compressive strength. The surplus

was left as a spare for unforeseen situations during the handling of the tests. The number of parts used in each batch for the controlled tests was as follows:

Geometric characterization: 10 pieces
Initial water absorption: 10 pieces
Simple compressive strength: 10 pieces

To carry out these tests, the recommendations of NTCM-23 (Complementary Technical Standards for the Design and Construction of Masonry Structures) and the standards of the National Organization for Standardization and Certification of Construction and Building (ONNCCE) (NMX-C-404-2012-ONNCCE) were met.

In addition, the compressive strength of the glue mortar was examined, for which 9 cubic specimens were manufactured and tested according to the specifications of NMX-C-486-2014-ONNCCE (Structural Use Mortar-Specifications and Test Methods).

The tests of the brick pieces and the mortar were carried out in the Laboratory of Soil Mechanics, Strength of Materials and Concrete Technology, of the Faculty of Engineering of the Universidad Autónoma de Chiapas (UNACH).

Procedure for Compressive Strength Test

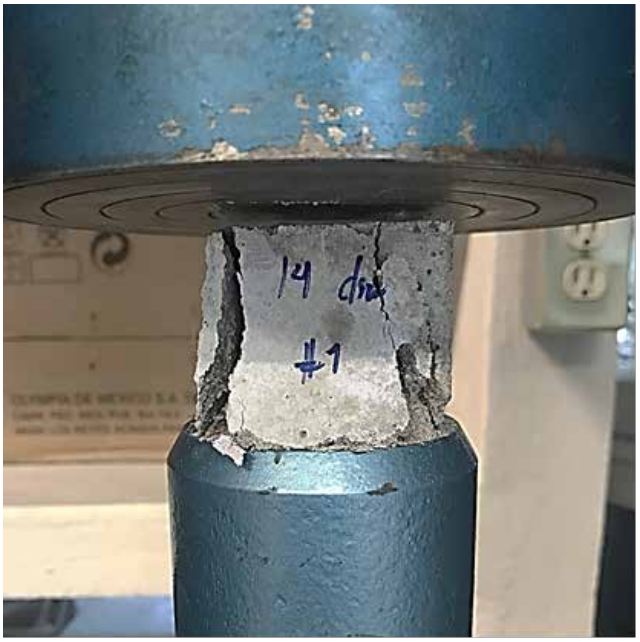
The mortar mixture was manufactured with cement (CPC type) whose characteristics comply with the recommendations of NMX-C-021-ONNCCE-2015 and NMX-C-414-ONNCCE-2017. Local river sand was also used. The volumetric proportion of the mix was 1:0:3 (cement-lime-sand), commonly used in local practice and classified as type I mortar following NTCM-23.

The controlled tests were carried out by NMX-C-061-ONNCCE-2010. Steel molds with dimensions of 5×5×5 cm^3 were used to prepare the mortar specimens (Figure 1). The molds were filled in two layers of mortar and compacted with 32 blows. The mortar was left to set for 24 hours, after which it was demolded and immersed in water for 27 days, and compressive strength tests were performed at 28 days of age.

Note: Own elaboration.

Figure 1. Mortar test tubes

Compression tests were performed using a universal press, as shown in Figure 2. The load was applied to the face of the test tube that was in contact with the vertical walls of the mold and maintained until the point of rupture.



Note: Own elaboration.

Figure 2. Compression test on a mortar specimen

Procedure for geometric characterization of the AMB

To perform the geometric characterization, we proceeded according to the protocol of NMX-C-038-ONNCCE-2013, and 10 pieces of ABM were chosen for each supplier. The dimensions (length, height, and width) of each piece of brick were measured with a Vernier (caliper) and a graduated ruler (Figure 3). Three measurements were made on each side, and the average and standard deviation of the dimensions recorded for each lot were calculated.

Note: Own elaboration.

Figure 3. ABM geometric characterization

Procedure for 24-hour water absorption

In order to determine the water absorption after 24 hours, we proceeded as described in NMX-C-037-ONNCCE-2013. Three brick samples were chosen for each supplier and marked with a number and a letter of the alphabet for proper identification (Figure 4).

Note: Own elaboration.

Figure 4. Specimens with identification

The samples were oven dried for 24 h at a temperature of 100 ± 10 °C (Figure 5). Subsequently, the dry mass value (*Ms*) of each sample was obtained. These were submerged in water at a temperature between 17°C and 23°C for a period of 24 hours. After this time, they were removed from the container, and the excess water on the surface of the samples was eliminated with a flannel, thus obtaining the value of the saturated mass and dry surface (*Msss*).

Note: Own elaboration.

Figure 5. Specimen drying process

With the recorded *Ms* and *Msss* data, the volumetric absorption (A) in percentage after 24 hours was calculated with equation 2:

$$A = \frac{Msss - Ms}{Ms} \times 100 \quad (1)$$

Procedure for volumetric weight

From each supplier, 10 pieces of LBR were selected, the dimensions of which were measured, and the dry mass of each brick was recorded. The volumetric weight was calculated by dividing the mass of the brick by its volume. These values were compared with those specified in NTCM-23, which establishes a standard volumetric weight of 1300 kg/m³ for solid artisanal clay partitions.

Compressive strength test on brick parts

Compressive strength tests were performed in accordance with NMX-C-036-ONNCCE-2013. In the 10 brick pieces chosen for this test, a pitching process was applied on both sides with a gypsum-based paste, as shown in

Figure 6. This procedure aims to achieve a uniform contact surface between the brick and the universal press, which allows for improving the distribution of the load on the brick piece.

The load was applied in a gradual and controlled manner on the major surface of the brick pieces. The last recorded load was the one that was reached at the time of the rupture of the material.

Note: Own elaboration.

Figure 6. Pitching of the brick pieces

In NTCM-23, it is indicated that the design compressive strength of individual parts must be calculated with equation 3:

$$f'_p = \frac{\overline{f}_p}{1 + 2.5C_p} \tag{3}$$

Where, $\overline{f}_p$, is the average of the compression strength of the pieces, referred to the gross area, and C_p is the coefficient of variation of the compression strength of the pieces, which in the case of handmade production pieces should not be less than 0.35.

RESULTS AND DISCUSSION

This section presents the results obtained from the different tests carried out on LBR parts, manufactured in the metropolitan region of Tuxtla Gutiérrez, Chiapas. The tests included evaluations of the geometric dimensions, water absorption percent, volumetric weight, and compressive strength of the parts. Each controlled test was conducted to determine how these properties affect the quality and applicability of brick in the construction of masonry walls.

Compressive strength of the glue mortar

Table 1 shows the results of the final load recorded and the values of the compressive strength at the age of 28 days for each test tube of mortar specimen.

Table 1
28-day mortar specimen compression test results

Test tube number	Breaking load (kg)	Compressive strength $\overline{f}_j$ (kg/cm²)
1	6000.00	240.00
2	6100.00	244.00
3	7100.00	284.00
4	5800.00	232.00
5	6000.00	240.00
6	5800.00	232.00
7	6800.00	272.00
8	6200.00	248.00
9	5800.00	232.00

The average value of the final load applied (Table 1) was 6177.78 kg, with a standard deviation (σ) of 465.78 kg. The average compressive strength determined was 247.11 kg/cm², with a standard deviation (σ) of 18.63 kg/cm².

According to NTCM-23, the design compressive strength (f'_j) of the mortar test tubes was calculated with equation 1.

$$f'_j = \frac{\overline{f}_j}{1 + 2.5C_j} \tag{1}$$

Where C_j is the coefficient of variation of the compressive strength of the mortar, which in no case will be taken less than 0.20, and $\overline{f}_j$ is the average compressive strength of each mortar specimen.

The results obtained for f'_j' are shown in Table 2 using the values in Table 1. According to the data in Table 2, the average value of the compressive design strength is 164.74 kg/cm², and its standard deviation is 12.42 kg/cm².

From these results, it was observed that the mortar performs well in compression tests. According to NTCM-23, the minimum design compressive strength, f'_j, for glue mortar must be 125 kg/cm². According to the results of Table 2, it can be seen that all the specimens satisfactorily complied with the regulations. Therefore, the material can be considered of appropriate quality, and the dosage of cement:lime:sand of 1:0:3 commonly used in local construction practice is adequate.

Table 2
28-day mortar specimen design compression strength

Test tube number	Design compressive strength f'_j (kg(cm²)
1	160.00
2	162.67
3	189.33
4	154.67
5	160.00
6	154.67
7	181.33
8	165.33
9	154.67

AMB Geometric variation

The average values of the ABM dimensions: length, width, and height of each supplier, are shown in Table 3, as well as the respective values of the standard deviation (σ).

Table 3
ABM mean value and standard deviation of geometric dimensions

Provider	Length (cm)	σ_{legth} (cm)	Width (cm)	σ_{width} (cm)	Height (cm)	σ_{height} (cm)
1	25.9133	0.0805	12.8866	0.1097	4.5400	0.1114
2	26.2533	0.2098	12.8800	0.1360	4.9433	0.1764
3	25.7700	0.2057	12.5800	0.3490	4.6266	0.4133
4	26.2300	0.2523	13.0166	0.1424	5.5200	0.1661
5	25.6966	0.3042	12.7233	0.1563	4.6466	0.2765
6	25.2866	0.1727	12.6200	0.1194	4.6733	0.0904
Total	25.8583	0.2042	12.7844	0.1688	4.8250	0.2057

The NMX-C-404-ONNCCE-2012 standard establishes that the manufacturing dimensions of clay partitions must comply with the following minimum requirements: 190 mm long, 100 mm wide, and 50 mm high, and that the actual dimensions must not differ by more than ± 3 mm from the other manufactured pieces.

Comparison of the data in Table 3 with the minimum requirements of NMX-C-404 indicates that, in general, the length and width dimensions of the pieces do comply; however, they do not meet the minimum height requirements. Specifically, Table 4 shows the suppliers that meet the minimum dimensions for length and width. In terms of height, only one of the six suppliers was able to meet the minimum dimension established.

Table 4
Revision of minimum dimensions on individual parts

Provider	Length	Width	Height
1	Complies	Complies	does not comply
2	Complies	Complies	does not comply
3	Complies	Complies	does not comply
4	Complies	Complies	Complies
5	Complies	Complies	does not comply
6	Complies	Complies	does not comply

Regarding the tolerance of ± 3 mm in individual parts, Table 5 shows that only supplier 3 does not comply with this tolerance for the width and height dimensions.

Table 5
Revisión de la tolerancia de ± 3 mm en piezas individuales

Provider	Length	Width	Height
1	Complies	Complies	Complies
2	Complies	Complies	Complies
3	Complies	does not comply	does not comply
4	Complies	Complies	Complies
5	Complies	Complies	Complies
6	Complies	Complies	Complies

Water absorption

The results of the 24-hour water absorption test are presented in Table 6. This table includes the average absorption values for each supplier and the standard deviation, as well as those corresponding to all the brick pieces analyzed.

According to NMX-C-404-ONNCCE-2012, the maximum water absorption level for clay pieces in a 24-hour period is 23%. The results shown in Table 6 indicate that three suppliers (3, 4, and 5) comply with this requirement, while the remaining three (1, 2, and 6) have absorption levels above the maximum level of the NMX-C-404 standard. Despite these variations, the average water absorption for the total number of pieces analyzed complies with the recommended level.

Table 6
Mean value and standard deviation of water absorption

Provider	*Ms* average (g)	σ_{dry} (g)	*Msss* average (g)	$\sigma_{saturated}$ (g)	% average absorption	$\sigma_{humidity}$ (%)
1	189.67	12.12	257.78	11.95	36.06	2.46
2	130.67	32.31	165.93	39.24	27.30	1.35
3	167.33	23.54	199.81	28.26	19.40	0.57
4	168.03	5.57	196.26	11.85	16.81	5.99
5	129.08	2.62	152.57	4.44	18.18	1.54
6	160.57	42.30	202.33	53.92	25.92	0.37
Total	157.56	19.74	195.78	24.94	23.95	2.05

Volumetric weight

Table 7 shows the average volumetric weights and standard deviations for each supplier. It also contains their respective values for the total population analyzed.

Table 7
Mean value and standard deviation of the volumetric weight

Provider	Volumetric Weight (kg/m³)	$\sigma_{Volumetric\ Weight}$ (kg/m³)
1	1500.00	100.00
2	1400.00	85.74
3	1600.00	68.74
4	1700.00	55.43
5	1600.00	58.39
6	1500.00	38.61
Total	1550.00	72.94

NTCM-23 establishes that the minimum net volumetric weight for handmade clay pieces in the dry state must be 1300 kg/m³. From the results in Table 7, it can be seen that all suppliers comply with this requirement.

Even when considering the higher value of the standard deviation (100 kg/m³ for supplier 1), the parts still meet this requirement.

Compressive strength in brick pieces

Table 8 shows the average values of ultimate load and compressive strength for each supplier, together with their standard deviations.

Table 8
Mean value and standard deviation of ultimate load and compressive strength of individual parts

Provider	Breaking load (kg)	σ_{carga} (kg)	Compressive strength $\overline{f_p}$ (kg/cm²)	$\sigma_{estress}$ (kg/cm²)
1	11916.70	5822.6961	31.8159	15.3714
2	22816.80	7476.5686	61.3298	19.8244
3	10227.70	5595.1417	24.2665	16.3864
4	24677.50	7379.7185	66.7251	20.1791
5	21305.50	5951.8540	56.9133	15.8609
6	8481.30	3274.103	22.8689	8.9726
Total	16570.90	5916.6803	43.9866	16.0991

According to NMX-C-441-ONNCCE-2013, it establishes that handmade partition pieces, for non-structural use, must have an average resistance of 30 kg/cm² and a minimum individual resistance of 24 kg/cm². The values in Table 8 show that the ABM pieces tested are suitable for non-structural use, except for those of supplier 6.

Using the values of the compressive stress $\overline{f_p}$ and the standard deviation of the stress (σ_{stress}) (Table 8), the coefficient of variation (C_p) was determined to calculate the design compressive strength.

The average values of the design compressive strength (f'_p) calculated with Equation 3, and for each supplier, are shown in Table 9. The values of the standard deviations and their coefficients of variation (C_p) are also shown. It is worth mentioning that for suppliers 2, 4, and 5, the value for C_p of 0.35 was used as indicated in NTCM-23.

The results of the design compressive strength, presented in Table 9, show that no supplier meets the minimum strength of 60 kg/cm² established by the NTCM-23 ABM standard, which is insufficient for this parameter. The resistance deficit varies between suppliers, reaching 84.95% in the case of supplier 3 and 36.67% in the case of supplier 4.

Table 9
Mean value, standard deviation, and coefficient of variation of the individual pieces' design compressive strength

Provider	f'_p (kg/cm²)	$\sigma_{f'_p}$ (kg/cm²)	Coefficient of variation C_p
1	14.4104	6.9617	0.4831
2	33.9193	10.9627	0.3232
3	9.0272	6.0952	0.6752
4	37.9972	11.4904	0.3024
5	33.5433	9.3485	0.2787
6	11.5449	4.5291	0.3923
Total	23.4070	8.2313	0.4092

The low design compressive strength observed in the brick pieces indicates that a good-quality masonry cannot be considered. It should be noted that mud bricks require sufficient mechanical strength to ensure adequate load transmission; in addition to ensuring durability, it significantly contributes to the stability and strength of the walls.

CONCLUSIONS

The design compressive strength of the glue mortar complied with what was indicated in NTCM-23 for type I mortar, being that the cubic specimens showed resistance capacities higher than the minimum value of 125 kg/cm², which indicates that the mortar used in the usual local practice was considered adequate and of good quality.

The masonry units analyzed met the minimum dimensions of length and width specified in NMX-C-404-ONNCCE-2012, although in most cases the minimum required height was not reached. It was found that the pieces of almost all suppliers remain within the tolerance of ± 3 mm in relation to the established manufacturing dimensions.

Regarding the percentage of water absorption, it is observed that only the bricks of three of the six suppliers were below the maximum limit of 23%, which suggests adequate permeability. However, the masonry units of the remaining three suppliers showed absorption levels higher than 23%, which indicates a higher porosity than recommended.

All the volumetric weight values of the pieces evaluated met the minimum of 1300 kg/m³ for artisanal clay partitions, as recommended by NTCM-23. However, as not all parts reached an adequate level of water absorption, it is necessary to improve the compaction and vibrating processes of the clay paste to optimize the correlation between porosity and volumetric weight.

Regarding the design compressive strength, the pieces tested were very poor, since none met the minimum value of 60 kg/cm² for solid artisanal clay partitions established by NTCM-23. Therefore, these pieces are not suitable for use in load-bearing walls, although they can be used in non-structural applications.

According to the results presented, it is necessary to improve the pieces' geometrical uniformity. Although they exceed the minimum length and width dimensions recommended by NMX-C-404-ONNCCE-2012, there is significant variability between different suppliers. In addition, it is crucial to optimize the pieces' porosity so that they do not exceed 23% water absorption, as stipulated by the same regulations. By achieving this, it is considered that the adhesion between the brick and the mortar can be improved, thus increasing the durability of the pieces.

Finally, it is considered very necessary to regulate and control more effectively the local handmade mud brick manufacturing process in order to improve the quality of the material. This will ensure that the masonry walls built in Tuxtla Gutierrez have adequate strength and meet the required safety and quality standards.

REFERENCES

Aguilera Morán, M. D. (2016). *Caracterización de las propiedades físico-químicas del tabique de barro recocido para la ciudad de Aguascalientes y área conurbada* [Tesis de maestría, Universidad de Aguascalientes]. Repositorio institucional de la Universidad de Aguascalientes http://bdigital.dgse.uaa.mx:8080/xmlui/handle/11317/692?show=full

Arbildo Huamani B., Rojas Paco M. C. (2017). *Ensayo de compresión axial y compresión diagonal de especímenes de albañilería de ladrillos de arcilla (Hércules I) fabricados en la ciudad de Tacna*. Tesis de licenciatura. Universidad Privada de Tacna. https://repositorio.upt.edu.pe/bitstream/handle/20.500.12969/335/Arbildo-Brayam-Rojas-Melany.pdf?sequence=1&isAllowed=y

Argüello Méndez, T. R. (2022). *La Producción de la Vivienda Popular en Tuxtla Gutiérrez, Chiapas*. Universidad Autónoma de Chiapas. https://drive.google.com/file/d/10JzDnA5C6fC75ypwrs6nw06I-pVFnL09/view?pli=1

Berríos Alvarado G. J., Gómez Bonilla J. H. (2015). *Revisión de la metodología de evaluación de la resistencia a compresión de la mampostería de barro cocido*. Tesis de licenciatura. Universidad de El Salvador. https://ri.ues.edu.sv/id/eprint/8652/1/Revisión%20de%20la%20metodología%20de%20evaluación%20de%20la%20resistencia%20a%20la%20compresión%20de%20la%20mampostería%20de%20ladrillo%20de%20barro%20cocido.pdf

Meli R. (1975). Comportamiento sísmico de muros de mampostería. Instituto de Ingeniería, UNAM, *Serie Azul No. 352*. México, DF, abril, 114 pp.

Normas Técnicas Complementarias para Diseño y Construcción de Estructuras de Mampostería. (2023). *Gaceta Oficial de la Ciudad de México*.

Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación, S. C. (2010). Industria de la construcción - Cemento para albañilería (mortero) - Especificaciones y métodos de ensayo. (NMX-C-021-ONNCCE-2010).

Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación, S. C. (2013). Industria de la construcción - Mampostería – Resistencia a la compresión de bloques, tabiques o ladrillos y tabicones y adoquines – *Método de ensayo*, (NMX-C-036- ONNCCE-2013).

Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación, S. C. (2014). Industria de la construcción - Cementantes hidráulicos - Especificaciones y métodos de ensayo, (NMX-C-038-ONNCCE-2013).

Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación, S. C. (2012). Industria de la construcción – Mampostería

– Bloques, tabiques o ladrillos y tabicones para uso estructural – Especificaciones y métodos de ensayo, (NMX-C-404-ONNCCE-2012).

Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación, S. C. (2014). Industria de la construcción - Cementantes hidráulicos - Especificaciones y métodos de ensayo, (NMX-C-414-ONNCCE-2014).

Organismo Nacional de Normalización y Certificación de la Construcción y la Edificación, S. C. (2010). Industria de la construcción - Cementos hidráulicos - Determinación de la resistencia a la compresión de cementantes hidráulicos, (NMX-C-061-ONNCCE-2010).

Piscal Arévalo, C. M., Afanador García, N., & Medina, S. (2012). Resistencia a la comprensión de ladrillos en el municipio de Ocaña. *Revista Ingenio. 4*(1), 12–17. https://revistas.ufps.edu.co/index.php/ingenio/article/view/1998

Soto G. F., Sánchez L. P. (2017). Estudio comparativo de la resistencia a compresión, absorción y dimensionamiento del ladrillo rafón producido en Quimistán, Chamelecón y Florida, Honduras. *Inovare Ciencia y Tecnología, 6*(1), 97-116. https://unitec.edu/innovare/published/volume-6/number-1/616-estudio-comparativo-de-la-resistencia-a-la-compresion-absorcion-y-dimensionamiento-del-ladrillo-rafon-producido-en-quimistan-chamelecon-y-florida-honduras.pdf

Valdivia Espinoza C. (2020). *Determinación de la resistencia a la compresión axial y resistencia al corte de la albañilería de ladrillos pandereta de arcilla fabricado de manera industrial en la ciudad de Huánuco*. Tesis de licenciatura. Universidad Nacional Hermilio Valdizán. https://repositorio.unheval.edu.pe/handle/20.500.13080/5816

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Identification of reflective students in higher education institutions in Mexico

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— Abstract—

The following article, *Identification of reflective students in higher education institutions in Mexico*, has an added value emanated from the research on *Reflective learning in higher education students in Mexico*, led by the academic group "*Studies in innovative organizational practices*" with the collaboration of the Research Network, *Organizational and business development*, in the period between 2022 and 2023, to a population of 2,172 students (44% female, and 56% male), with an age range of 18 to 26 years, who were enrolled in eleven educational programs, from six higher education institutions in Mexico (FCyA CI and FI of the Autonomous University of Chiapas (UNACH) and ITTG, in Chiapas; ITCJ and UTCJ in Ciudad Juarez, Chihuahua; and the UAEMex, in the State of Mexico). Results demonstrate that from the study participants, only one student was highly reflective when answering the first six questions of the questionnaire. The said respondent was male and enrolled in the fourth semester of the Bachelor's Degree in Computer Systems at the Accounting and Administration Faculty (FCyA), Campus I of the UNACH. Employing variable data analysis, we found that only a few students managed to answer up to question four, and on occasions up to question five. It is important to note these results to comply with the intended objectives.

The results of the statistical analysis of the "gender variable" with the "reflective responses variable" of question 1 support the research hypothesis with a confidence level of 95%. Thus, the relationship between the variables is significant; it is concluded that the reflective responses provided by the members of the sample group do have a significant relationship with their gender.

Keywords:

Learning; reflection; reflective students; reflective thinking; HEI..

This work is a continuation of the research on Reflective Learning among Higher Education Students in Mexico, carried out by the Academic Body "Study of Innovative Organizational Practices", attached to the Faculty of Accounting and Administration C-I (FCyA C-I) of the Universidad Autónoma de Chiapas (UNACH), in collaboration with the Research Network "Organizational and Business Development" based at the Instituto Tecnológico de Ciudad Juárez, Chihuahua, during March 2022 to September 2023, in which six Higher Education Institutions (HEIs) participated, the results of which were presented in the final report to the General Directorate of Research and Postgraduate Studies of the UNACH.

The main objective of the aforementioned research was to know to what extent higher education students in Mexico make use of reflective processes in their learning strategies during their professional training, given that, according to the literature consulted for the construction of the theoretical framework, the reflective moment seems to be a different stage and perhaps superior to the types of learning by reasoning and rote, without detracting from the importance they have in the learning processes in all areas of knowledge.

As an instrument for collecting empirical data, a questionnaire created in 2003 was used to investigate organizational learning within the framework of the completion of the doctoral thesis *Organizational Learning: Nature, Evolution, and Perspectives, a case study in four organizations in Mexico* (Moguel, 2003) in the Graduate Course in Organizational Studies at the Universidad Autónoma Metropolitana Campus Iztapalapa, in which how people learn in the organizational environment was examined, where the hypothesis was that three types of learning can occur: memoristic (ontic), reasoning (ontological), and reflective (epistemic), and for its application in research on reflective learning in university studies, the pertinent adaptations were carried out.

In the case of research on reflective learning in higher education students in Mexico, the following HEIs participated; the Faculty of Accounting and Administration C-I (FCyA C-I) of the Universidad Autónoma de Chiapas (UNACH), the Instituto Tecnológico de Ciudad Juárez (ITCJ), Chihuahua, the Instituto Tecnológico de Tuxtla Gutiérrez (ITTG), Chiapas, the Universidad Autónoma del State of Mexico (UAEmex), the Universidad Tecnológica de Ciudad Juárez (UTCJ), Chihuahua, and the Faculty of Engineering (FI) of the Universidad Autónoma de Chiapas.

The bachelor's degrees or educational programs included are: Civil Engineering (IC), Electromechanical Engineering (IEM), Business Management Engineering (IGE), Logistics Engineering (IL), Computer Systems Engineering (ISC), Industrial Engineering (II), Mechanical Engineering (IM), Bachelor's Degree in Administration (LA), Bachelor's

Degree in Accounting (LC), Bachelor's Degree in Tourism Management (LGT), and Bachelor's Degree in Computer Systems (LSC); eleven in total, seven from the engineering area and four from the administrative-accounting area.

The observed population was 2172 students; of these, 982 (44.3%) are women and 1210 (55.7%) are men, from the aforementioned HEIs and educational programs.

The data collection instrument used contains 24 questions; the first six are multiple-choice, and questions seven through 24 are structured on a Likert scale. The work presented here explores only the behavior of the first six questions, which consist of a reflective option, a reasoning option and two memory options, prepared taking into account the theoretical contributions of the authors consulted with the characteristics of reflective people, both in the organizational learning thesis (Moguel, 2003) and in the research of reflective learning in HEIs in Mexico. So, what we are interested in is knowing how many students in the population answered the reflective options in each question, and thus determine which of them are reflective in their professional studies and surely in the other roles of their lives.

Reliability of the research instrument

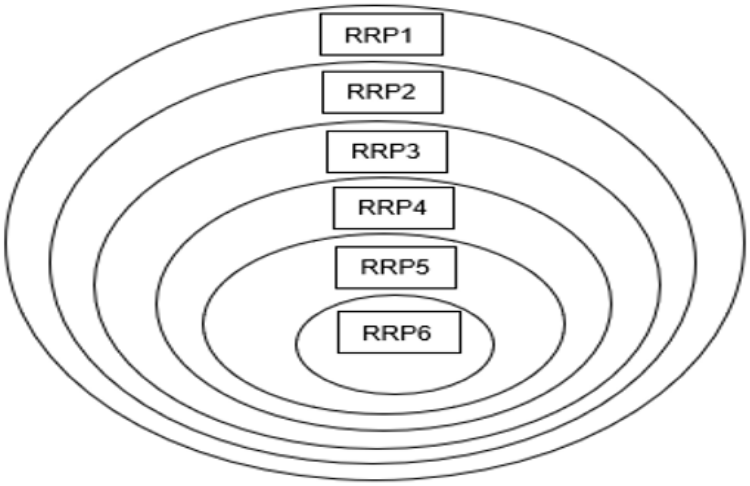
In relation to the reliability of the research instrument, we have the following: the Cronbach's Alpha coefficient obtained for the complete questionnaire in the SPSS program is 0.888 with 18 elements, a result that, according to the theory in the field, can be qualified as an instrument of high reliability. The 18 elements refer to the items in the Likert scale - from question seven to question 24 - with which this scale works. To determine the reliability of questions one to six, the object of this study, we proceeded to their statistical calculation in Excel with the 2172 records of the original study, obtaining a reliability of 0.60, which is considered reliable. In addition, the application of the instrument at two different times, the data concerning cognitive moments are as follows: memory (2003, 14%; 2023, 18%), reasoning (2003, 74%; 2023, 68%), and reflection (2003, 12%; 2023, 14%), a situation that reflects a fairly consistent behavior with twenty years of difference in its application. Therefore, the research instrument can generally be considered to be reliable according to Hernandez et. al (2014).

With the arguments set out above and following Hernández et. al. (2014), it can be said that the research instrument applied in both studies, both in the original work of 2003 and for the research of reflective students in the year 2023, shows an acceptable internal consistency.

II. METHOD

To carry out this study in the field of qualitative tradition, although a statistical analysis section is included that suggests a mixed-cut research, a filtering methodology was developed in each question, that is, taking as its main input the database of 2172 records in the Excel program of the original study and using the filters in each item, a sieve of reflective answers is carried out in question one; from that set of reflective answers the reflective answer of question two is filtered; from that set of reflective answers the reflective answer of question three is filtered, from that set of reflective answers the reflective answer of question four is filtered, from that set of reflective answers the reflective answer of question five is filtered, and finally, from that set of reflective answers the reflective answer of question six is filtered.

The following figure makes this procedure visible from set theory, where RRP means reflective answer per question.

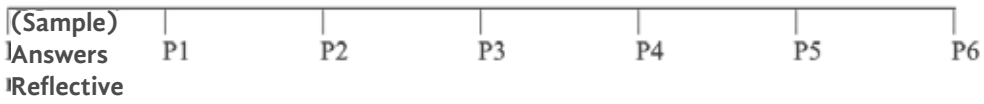


Note: Own elaboration.

Figure 1. Reflective answer sets from question 1 to question 6

To operationalize this process, a method called "Reflective Answer Line" is established in which the first six questions of the questionnaire are represented with the initials P1, P2, P3, P4, P5, and P6 -preposing at the beginning of the line, before P1, the corresponding sample of the variable under analysis- in which the number of reflective answers in each of the questions is indicated, and as can be assumed, the reflective answers are drastically decreasing from question 1 to question 6, as will be observed in the subsequent analyses; being precisely this phenomenon what we are interested in studying: how many students are reflective in each of the variables, it is even possible to identify said students to know their qualities and study

habits that make them a highly reflective student, according to our analysis instrument. Diagram 1 illustrates this procedure.



Note: Own elaboration.

Diagram 1. Reflective Response Line

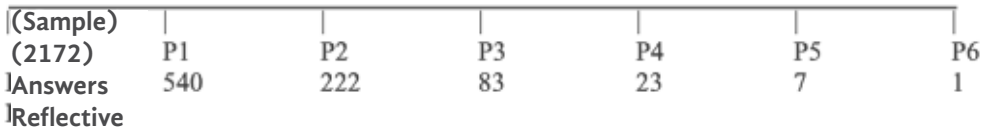
Next, the identification analysis of reflective students is carried out on the main variables established, such as: study of the total population, institutions of higher education (HEIs), educational programs, and gender; in all cases, the observations are made via the filters of reflective responses indicated above.

1. Analysis of the total population of the original study, 2172 students

Under the filtration methodology explained above, of the total population of 2172 students from the six participating HEIs between November 2022 and May 2023, the following results are found:

For question 1, there were 540 reflective answers (25%).
For question 2, there were 222 reflective answers (41%).
For question 3, there were 83 reflective answers (37%).
For question 4, there were 23 reflective answers (28%).
For question 5, there were 7 reflective answers (30%).
For question 6, there was 1 reflective answer (14%).

Using the answer row, we have the following representation.



Note: Own elaboration.

Diagram 2. Reflective response row for the total population

This means that of the total sample of 2172 students:

- 540 answered the reflective option in question 1; of them...
- 222 answered the reflective option of question 2; of them...
- 83 answered the reflective option of question 3; of them...
- 23 answered the reflective option of question 4; of them...

- 7 answered the reflective option of question 5; and of them...
- 1 answered the reflective option of question 6.

Since the study makes it possible to identify the student in all his or her qualities, and in order to preserve his or her identity, only general information is referred to. The person who answered the six reflective answers is a male student, studying the fourth semester of the Bachelor's Degree in Computer Systems, in the FCyA C-I of the UNACH, a situation that allows us to monitor his school performance in the subsequent cycles.

The seven students who gave reflective answers to question five have the following characteristics:

HIEs	Bachelor's Degree	Semester	Gender	Age
UTCJ	ISC	5	M	19-22
FCA	LC	9	M	19-22
FCA	LSC	9	M	23-25
FCA	LA	9	F	23-25
FCA	LA	9	F	19-22
FCA	LSC	4	M	19-22
FCA	LGT	9	M	23-25

The table of data shows that of the seven students; one belongs to the Universidad Tecnológica de Ciudad Juárez, enrolled in the PE of Engineering in Computer Systems, fifth semester, male; and six belong to the Faculty of Accounting and Administration C-I of the Universidad Autónoma de Chiapas, of which two are enrolled in the Bachelor's Degree in Administration, two in the Bachelor's Degree in Computer Systems, one in the Bachelor's Degree in Accounting and one in the Bachelor's Degree in Tourism Management; five of them are in the ninth semester and one in fourth; four are male and two are female, information that seems relevant to us to affirm that graduates of the educational programs of the FCyA C-I of the UNACH show an important reflective component.

With the same procedure, the analysis of the research variables continues, namely: HEIs, bachelor's degrees or educational programs, and gender

2. Higher Education Institutions Analysis

We proceed to do a study on the HEIs.

2.1) UNACH's Faculty of Accounting and Administration C-I, whose sample amounts to **1196** students, with the following results.

For question 1, we found 291 reflective answers (24%); for question 2, we found 121 (42%); for question 3, we found 43 (35%); for question 4, 13 were found (30%); for question 5, 6 were found (46%); and for question 6, 1 was found (17%). The graphical representation of the answer row is as follows.

(Sample) (1196)	P1	P2	P3	P4	P5	P6
Answers Reflective	291	121	43	13	6	1

Note: Own elaboration.

Diagram 3. Reflective response row for the sample of the UNACH's FCyA C-I

Six students answered the reflective responses up to question five, plus the student who answered up to question six, whose characteristics coincide with the information of the FCyA C-I students who appear in the previous analysis; therefore, their identification is obviated.

2.2) Instituto Tecnológico de Ciudad Juárez, Chihuahua (ITCJ), whose sample amounts to 537 students, with the following results.

For question 1, we found 135 reflective responses (25 %); for question 2, we found 50 (37 %); for question 3, we found 21, (42 %); for question 4, we found 6, (28 %); for question 5, we found 0; for question 6, we found 2. The graphical representation of the answer row is as follows.

(Sample) (537)	P1	P2	P3	P4	P5	P6
Answers Reflective	135	50	21	6	0	2

Note: Own elaboration.

Diagram 4. Reflective Response row for the ITCJ sample

In this ITCJ exercise, six students answered reflectively up to question four; in question five there are zero reflective answers, however, in question six there are two reflective answers, these students have the following characteristics: both are male, one from the administration degree, eighth semester; and one more from the ninth semester of electromechanical engineering.

2.3) Instituto Tecnológico de Tuxtla Gutiérrez, Chiapas (ITTG), whose sample amounts to 121 students, with the following results.

For question 1, we found 39 reflective answers (32%); for question 2, we found 18 (46 %); for question 3, we found 3 (17 %); for questions 4, 5, and 6, we found 0 reflective answers.

The graphical representation of the answer row is as follows.

(Sample) (121)	P1	P2	P3	P4	P5	P6
Answers Reflective	39	18	3	0	0	0

Note: Own elaboration.

Diagram 5. Reflective Response row for the ITTG sample

Three students gave reflective answers up to question three; there are no reflective answers to questions four, five, and six.

2.4) Universidad Autónoma del Estado de México (UAEMex), whose sample amounts to 119 students, with the following results.

For question 1, we found 35 reflective answers (29%); for question 2, we found 18 (51%); for question 3, we found 10 (55%); for question 4, we found 1 (10%); for questions 5 and 6, we did not find any reflective answers. The graphical representation of the answer row is as follows.

(Sample) (119)	P1	P2	P3	P4	P5	P6
Answers Reflective	35	18	10	1	0	0

Note: Own elaboration.

Diagram 6. Reflective answers line for the UAEMex sample

One male student gave reflective answers up to question four; he is enrolled in the tenth semester of the Computer Systems Engineering program.

2.5) Universidad Tecnológica de Ciudad Juárez, Chihuahua (UTCJ), whose sample amounts to 113 students, with the following results.

For question 1, we found 25 reflective answers (22%), for question 2, we found 11 (44%); for question 3, we found 4 (36%); for question 4, we found 2 (50%); for question 5, we found 1 (50%); for question 6, we didn't find any reflective answers.

The graphical representation of the answer row is as follows.

(Sample) (113)	P1	P2	P3	P4	P5	P6
Answers Reflective	25	11	4	2	1	0

Note: Own elaboration.

Diagram 7. Reflective response row for the UTCJ sample

One male student gave reflective answers up to question five; he is enrolled in the fifth semester of the Computer Systems Engineering program.

2.6) Facultad de Ingeniería FI de la Universidad Autónoma de Chiapas, whose sample amounts to 81 students, with the following results.

For question 1, we found 15 reflective answers (18%); for question 2, we found 4 (27%); for question 3, we found 2 (50%); for question 4, we found 1 (50%); for questions 5 and 6, we didn't find any reflective answers. The graphical representation of the answer row is as follows.

(Sample) (81)	P1	P2	P3	P4	P5	P6
Answers Reflective	15	4	2	1	0	0

Note: Own elaboration.

Diagram 8. Reflective response row for the UNACH FI sample

One male student gave reflective answers up to question four; he is enrolled in the first semester of the Civil Engineering PE.

3. Analysis by Bachelor's Degree or Educational Program

As mentioned since the beginning of this work, the number of educational programs or bachelor's degrees in analysis adds up to eleven, seven from the field of engineering and four from the area of accounting-administrative sciences. However, since the exercise of answering all the reflective answers of the six questions under analysis is not an easy task, those HEIs whose educational programs have small samples, less than 100 records, seem to have little chance of manifesting the existence of reflective students in their ranks, and therefore the search possibilities are significantly reduced, so that the work team has made the decision to carry out the study of identification of reflective students only in educational programs whose sample exceeds one hundred (100) records, such as the following cases: LA, LC, LSC, ISC, LGT and II, leaving out of the analysis the PEs with less than 100 records, such as: IC, IEM, IM, IGE and IL. The educational programs that meet this condition are then analyzed.

3.1) Bachelor of Administration (BA), whose sample amounts to 471 students, with the following results.

For question 1, we found 125 reflective answers (26%); for question 2, we found 47 (38%); for question 3, we found 17 (36%); for question 4, we found 5

(29%); for question 5, we found 2 (40%); for question 6, there were 0 reflective answers. The graphical representation of the answer row is as follows.

(Sample) (471)	P1	P2	P3	P4	P5	P6
Answers Reflective	125	47	17	5	2	0

Note: Own elaboration.

Diagram 9. Reflective response row for the PE LA sample

Two students gave reflective answers up to question five, and have the following characteristics: they are female, enrolled in the ninth semester at the FCyA C-I of the UNACH.

3.2) Bachelor of Accounting (LC), whose sample amounts to 403 students, with the following results.

For question 1, there were 87 reflective answers (21%); for question 2, there were 41 (47%); for question 3, there was 1 (29%); for question 4, there were 3 (25%); for question 5, there was 1 (33%); for question 6, there were 0 reflective answers. The graphical representation of the answer row is as follows.

(Sample) (403)	P1	P2	P3	P4	P5	P6
Answers Reflective	87	41	12	3	1	0

Note: Own elaboration.

Diagram 10. Reflective response row for the PE LC sample

One male student gave reflective answers up to question five, and belongs to the ninth semester of the FCyA C-I.

3.3) Bachelor's Degree in Computer Systems (LSC), whose sample amounts to 330 students, with the following results.

For question 1, we found 72 reflective answers (22%); for question 2, we found 30 (42%); for question 3, we found 16 (53%); for question 4, we found 5 (31%); for question 5, we found 2 (40%); for question 6, we found 1 (50%). The graphical representation of the answer row is as follows.

(Sample) (330)	P1	P2	P3	P4	P5	P6
Answers Reflective	72	30	16	5	2	1

Note: Own elaboration.

Diagram 11. Reflective response row for the PE LSC sample

The information highlights that one student answered the six reflective questions; consequently, it is the same student identified in previous male variables of the fourth semester, enrolled in LSC. Two students gave reflective answers to question five, and these are the same as those of the FCyA C-I, one of them from the ninth semester, and the aforementioned student.

3.4) Engineering in Computer Systems (ISC), whose sample amounts to 291 students, with the following results.

For question 1, we found 84 reflective answers (29%); for question 2, we found 38 (45%); for question 3, we found 18 (47%); for question 4, we found 3 (17%); for question 5, we found 1 (33%); for question 6, there were 0 reflective answers. The graphical representation of the answer row is as follows.

(Sample) (291)	P1	P2	P3	P4	P5	P6
Answers Reflective	84	38	18	3	1	0

Note: Own elaboration.

Diagram 12. Reflective response row for the PE ISC sample

One student gave the reflective answers up to question five, and it is the same male student enrolled in the fifth semester at the UTCJ.

3.5) Bachelor's Degree in Tourism Management (LGT), whose sample amounts to 243 students, with the following results.

For question 1, we found 68 reflective answers (28%); for question 2, we found 25 (37%); for question 3, we found 28 (20%); for question 4, we found 2 (40%); for question 5, we found 2 (50%); for question 6, there were 0 reflective answers. The graphical representation of the answer row is as follows.

(Sample) (243)	P1	P2	P3	P4	P5	P6
Answers Reflective	68	25	5	2	1	0

Note: Own elaboration.

Diagram 13. Reflective response row for the PE LGT sample

One male student gave reflective answers up to question five, enrolled in the ninth semester of the UNACH's FCyA C-I.

3.6) Industrial Engineering (II), whose sample amounts to 168 students, with the following results.

For question 1, we found 45 reflective answers (27%); for question 2, we found 18 (40%); for question 3, we found 6 (33%); for question 4, we found 2 (33%); for questions 5 and 6, there were no reflective answers.

Its graphical representation is as follows.

(Sample) (168)	P1	P2	P3	P4	P5	P6
Answers Reflective	45	18	6	2	0	0

Note: Own elaboration.

Diagram 14. Reflective response row for the PE II sample

Two students (male and female) gave reflective answers up to question four, enrolled in the fifth semester at ITCJ.

4. Analysis by Gender

4.1) Female, whose sample amounts to 962 students, with the following results.

For question 1, we found 213 reflective answers (22%); for question 2, we found 97 (45%); for question 3, we found 22 (23%); for question 4, we found 7 (32%); for question 5, we found 2 (28%); for question 6, there were 0 reflective answers. The graphical representation of the answer row is as follows.

(Sample) (962)	P1	P2	P3	P4	P5	P6
Answers Reflective	213	97	22	7	2	0

Note: Own elaboration.

Diagram 15. Reflective answers row for Females

Two female students gave reflective answers up to question five; they are enrolled in the ninth semester at the LA of UNACH's FCyA C-I.

4.2) Males, whose sample amounts to 1210 students, with the following results.

For question 1, we found 327 reflective answers (27%); for question 2, we found 125 (38%); for question 3, we found 61 (49%); for question 4,

we found 16 (29%); for question 5, we found 5 (26%); for question 6, there was 1 reflective answer (20%). The graphical representation of the answer row is as follows.

(Sample) (1210)	P1	P2	P3	P4	P5	P6
Answers Reflective	327	125	61	16	5	1

Note: Own elaboration.

Diagram 16. Reflective answers row for Male samples

Five male students answered the reflective answers up to question five, including the student who answered up to question six of the questionnaire, and have the following characteristics: one, belongs to the UTCJ, enrolled in the fifth semester at ISC; four belong to the UNACH's FCyA C-I, two enrolled in the LSC, one in the LC, and one in the LGT, three of them in ninth semester and one in fourth; includes the student who answered the six reflective options.

Statistical analysis between the variables gender and the reflective answer to question 1

As far as the components and data of the gender variable allow, the following, a goodness-of-fit test is performed, which is particularly useful when the data use the nominal scale, so it is possible to perform a hypothesis test with data classified in groups, as in our case, that are classified by sex, the purpose of the goodness-of-fit test is to compare a distribution of observed frequencies with a distribution of expected frequencies.

The analysis begins by preparing a table of observed frequencies and expected frequencies, that is, the responses provided by the students for the sex variable, in the first case, and the expected frequencies are calculated by dividing the total of the observed frequencies by two. As indicated in Table 1.

Table 1

Observed and expected frequencies of RRP1 in relation to the gender variable

	Reflective Answers for Question 1	
Gender	Seen Frequencies	Expected Frequencies
	fo	fe
Female	213	270
Male	327	270
Total	540	540

Note: Own elaboration.

Observing the behavior of the frequency distribution, the following question arises: Is it reasonable to conclude that there is no difference in the answers given by gender? If so, one would expect the observed frequencies to be equal or almost equal, in other words, one would expect the same number in the male category to be the same as in the female category in their reflexive answers to question 1; thus, any discrepancy between the observed and expected frequencies is attributed to chance, or a sampling error, so the following question must be asked: Is the difference found in the number of times the reflexive answer is selected due to chance or must one conclude that gender does influence this response?

To answer this question, we proceed to the formulation of the following hypothesis system: null hypothesis (Ho), and research hypothesis (Hi), where:

- **Ho: There is no significant difference between the observed and expected frequencies.**

Versus

- **Hi: There are significant differences between the observed and expected frequencies.**

Using a significance level of 5% means the probability of rejecting the null hypothesis when it is true.

The test statistic to be used is the Chi-square given by:

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

Where:

fo: observed frequencies, fe: expected frequencies

As indicated in Table 2.

Table 2

Observed and expected frequencies for calculating Chi-square

fo	fe	fo-fe	(fo-fe)^2	(fo-fe)^2/fe
213	270.00	-57.00	3249.00	12.03
327	270.00	57.00	3249.00	12.03
540				
			Chi-cuadrada	**24.07**

Note: Own elaboration.

Using the Chi-square formula and applying the data found above, we have:

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e} = \mathbf{24.07}$$

Therefore, the calculated Chi-square value is **24.07**.

Once the hypothesis system has been established for testing, a significance level of ∝ = 5% and a confidence level of Z= 95% is defined. Subsequently, the degrees of freedom for the Chi-square (gl) is calculated according to the procedure (number of columns-1) (number of rows-1), that is equal to (2-1) (2-1) = 1*1= 1.

With these data we locate the critical value of the Chi-square statistic in Table H, Chi-square distribution, in the book *Applied Statistics for Business and Economics*, Webster, Allen (2000) as follows: considering 1 gl and significance level ∝ = 5% it is found that the critical value expressed as $\propto_c^2$=**3.841**, which when compared with the calculated Chi-square value of 24.07 turns out to be lower, i.e., 3.841 < 24.07, a relationship that suggests taking the following decision:

Rejecting the null hypothesis and accepting the research hypothesis with a confidence level of 95%, i.e., the relationship between the variables gender and reflexive answer in question 1 is significant, in other words, they are dependent variables, it is concluded that the reflexive responses provided by the sample members do have a significant relationship with their gender.

III. RESULTS

This article, as stated at the beginning, is a continuation of the research *Reflective learning among higher education students* in Mexico (2022-2023), the results of which were presented in the final report, in various congresses on the subject, and in the book that is in the process of being edited for publication. The main objective of this research was to determine the degree to which higher education students in Mexico make use of reflective processes during their professional studies, since according to the literature consulted, the reflective moment seems to be a different stage and perhaps superior to the types of learning by reasoning and memorizing, without detracting from their importance in the learning processes in all areas of human knowledge.

A collateral objective was to know how many students among the population of 2172 were able to answer the reflective options of the first six questions of the questionnaire, in the intelligence that, in the Likert scale questions, from seven to 24, approximately 70 percent of them showed an orientation to learning by reasoning and it remained to analyze and identify the entirely reflective students in this sample. The procedure was explained in the section *method* of this work, obtaining the following results.

- Only one person, from among the population of 2172 students, was able to respond to the six reflective responses: a male student from the fourth semester of the LSC, at UNACH's FCyA C-I. Other six students managed to answer up to question five the reflective options: the first student is male and belongs to the UTCJ, enrolled in the PE of ISC in fifth semester; six belong to UNACH's FCyA C-I, two are enrolled in the LA, two in the LSC, one in the LC and one in the LGT; five of them are in ninth semester and one in fourth; four are male and two are female.

- In UNACH's School of Accounting and Administration C-I, with a sample of 1196 students, six students gave reflexive answers up to question five, plus the student who answered up to question six, whose characteristics coincide with the information of the students of FCyA C-I that appear in the previous analysis; therefore, their characterization is obviated.

- At the Instituto Tecnológico de Ciudad Juárez, with a sample of 537 students, six of them gave reflexive answers up to question four; they are enrolled in different educational programs between the fifth and tenth semesters; two are female and four are male.

- At the Instituto Tecnológico de Tuxtla Gutiérrez, with a sample of 121 students, three of them gave reflexive answers up to question three; there are no reflexive responses for questions four, five, and six.

- At the Universidad Autónoma del Estado de México, with a sample of 119 students, one male student gave reflexive answers up to question four; he's enrolled in the tenth semester of ISC.

- At the Universidad Tecnológico de Ciudad Juárez, with a sample of 113 students, one male student gave reflexive answers up to question five; he's enrolled in the fifth semester of ISC.

- In the Faculty of Engineering of the UNACH, with a sample of 81 students, one male student gave reflexive answers up to question four; he's enrolled in the first semester of IC.
- In the Bachelor's Degree in Administration, with a sample of 471 students, two female students gave reflexive answers up to question five; they're enrolled in the ninth semester at UNACH's FCyA C-I.

- In the Bachelor's Degree in Accounting, with a sample of 403 students, one male student gave reflective answers up to question five; he's enrolled in the ninth semester at the FCyA C-I.

- In the Bachelor's Degree in Computer Systems, with a sample of 330 students, one of them answered the six reflective questions; consequently, it is the same student identified in previous variables, he's male and enrolled in the fourth semester. Another male student answered reflectively up to question five; he was already identified in the ninth semester at the FCyA C-I.

- In Computer Systems Engineering, with a sample of 291 students, one male student gave reflective answers up to question five; he's the same one enrolled in the fifth semester at the UTCJ.

- In the Bachelor's Degree in Tourism Management, with a sample of 243 students, one male student gave reflective answers up to question five; he's enrolled in the ninth semester at UNACH's FCyA C-I.

- In Industrial Engineering, with a sample of 168 students, two of them (one male and one female) managed to give reflective answers up to question four, both enrolled in the fifth semester at the ITCJ.

- In relation to the female gender, with a sample of 962 students, two of them gave reflective answers up to question five, both enrolled in the ninth semester of the Bachelor's Degree in Administration at UNACH's FCyA C-I.

- Regarding the male gender, with a sample of 1210 students, five of them gave reflective answers up to question five, including the student who answered up to question six: one, belongs to the UTCJ, enrolled in the fifth semester at ISC; four belong to UNACH's FCyA C-I, two enrolled in the LSC, one in the LC, and one in the LGT, three of them in ninth semester and one in fourth; including the student who answered the six reflective options.

Regarding the statistical analysis between the observed frequencies and the expected frequencies with the reflective responses of question 1 in relation to the gender variable, it is observed that the research hypothesis is accepted with a confidence level of 95%, that is, the relationship between the gender and reflective answer variables of question 1 is significant, in other words,

they are dependent variables, it is concluded that the reflective responses provided by the members of the sample if they have a significant relationship with their gender.

IV. DISCUSSION

Learning techniques have evolved over the course of time, from the ancient Greeks who recognized themselves as great teachers of pedagogy and didactics - the Socratic method is an authentic process of reflection -, including the contributions of education in China, in India, in Egypt, in the Hebrew region; the Greek, Roman, medieval, positivist, and socialist pedagogical thought from the new school, critical pedagogical thinking; the development of learning theories: traditional, cognitive, modern theories; and today education mediated by information and communication technologies (ICTs) that represent a real revolution in the educational field with computers, mobile computers, the Internet, the Web, educational platforms, etc.

It can also be said that scientific and technological progress since it began almost 400 years ago, when René Descartes published his founding work *The Discourse of the Method* (1637), the process of accumulation of systematized and reliable knowledge and knowledge is detonated in all areas of knowledge, mainly in the natural sciences, through a unique privilege function of human beings: the intellect, which, according to our precursor studies, seems to occur in three moments of human cognition: memory, reasoning, and reflection, the latter being reflection, the true responsible for the development of societies and humanity, considering it the function where new ideas, new knowledge, innovations, creations, inventions, discoveries originate, which have allowed the current scientific and technological stage to be reached, without in most cases, researchers being aware of their reflective capacity and their reflective methodology (Alvesson & Skoldberg; 2000) applied in their creative processes.

The results obtained in this study indicate that only one student from the population of 2172 was able to answer the response options in the first six questions of the questionnaire applied in the research *Reflective learning in students of higher education in Mexico*. In that same sample, six more answered up to question five; when the data are analyzed by variables, that is, by HEIs, educational programs, and gender, the chances of finding reflective students visibly decrease, in many cases reaching only question four.

The above may be indicating the difficulties involved in reflective abilities in students of higher education in Mexico, with the characterizations of the variables included in the original study, such as HEIs, educational programs, gender, age (in a range of 18 to 26 years) and semester (from the first to the tenth, in some cases), in such a way that it is suggested the real identification

of students recognized as reflective in a general way and follow up on their study habits to learn more about them to be able to model, as far as possible, these outstanding students.

During the documentary research in relation to reflective learning, studies applied only to 15-year-old secondary school students (Laisequilla, 2018) were found, to analyze the results of the PISA test. Crespo-Cabuto, et. al. (2019) explored the psychometric properties of an instrument to measure reflective thinking skills in university students, in the State of Sonora, Mexico.

For his part, González-Moreno (2012) studies the formation of reflective thinking in students at a Catholic university in Bogotá, Colombia, taking as a sample only 25 women with an average age of 19 years in a Bachelor's Degree in Pedagogy, in a qualitative research. Gravini and Iriarte (2008) studied the metacognitive processes of students with different learning styles with a sample of four students from the eighth semester of the Bachelor's Degree in Psychology at the Universidad del Norte in Barranquilla, Colombia.

According to Piaget (1991), children begin their reflective behavior between the ages of seven and eight, when they begin to think before acting, resulting in a clear decrease in their impulsive behavior of early childhood (p. 57). According to Ruffinelli (2017), reflection represents a transversal axis in the training of teachers and one of the basic pillars of the teacher's profile as a reflective professional, prepared for this practice as a source of lifelong learning (p. 3).

The research *Reflective learning among higher education students in Mexico* was carried out with a population of 2172 (44% female and 56% male), with age ranges between 18 and 26 years, from the first to the tenth semester (in some cases), distributed in six HEIs and eleven educational programs.

V. CONCLUSIONS

Considering that the research instrument was the survey prepared since the doctoral thesis on organizational learning in 2003, and replicated with the own adjustments for its application in research on reflective learning in university students in 2023, it presents a high degree of reliability according to the Cronbach's Alpha Coefficient, as well as the reliability analysis prepared for the first six questions of the questionnaire is reliable, plus the consistency shown in the two aforementioned applications, according to Hernández, et. al. (2014) it can be said that the data analyzed and interpreted in this work have sufficient reliability from a scientific perspective.

By virtue of this, and since the research instrument was developed taking into account the theoretical foundations collected during the investigation of the state of the art on the phenomenon of reflective learning, it

can be said that it is not easy for students to respond to all the reflective options from questions one to six, as has been demonstrated in the fact that of the population of 2172 participating students only one was able to answer said block of questions to be considered as a highly reflective student, who is a male student enrolled in fourth semester of the Bachelor of Computer Systems, at UNACH's Faculty of Accounting and Administration C-I, a situation that allows the research team to follow him to observe his study habits and behaviors as a university student, as well as analyze his background in baccalaureate studies.

One should not lose sight of the students who answered up to question five, who have their merit because they have one reflective answer left to be considered highly reflective. They must also be monitored and observed during their school career, because they may favor in the future the approach to a reflective pedagogy in higher education students in Mexico, with the qualities and competitive advantages that in other sections and other studies have been documented.

Although this work aimed to identify reflective students in higher education institutions in Mexico, we are aware that the most important thing is to cultivate a reflective pedagogy aimed at creating reflective thinking habits among our students, which would result in a real competitive advantage as university students today and as successful professionals in the near future.

REFERENCES

Alvesson Mats y Kaj Skoldberg (2000) Reflexive Methodology, New Vistas for Qualitative Research. SAGE Publications, London.

Crespo-Cabuto, A, González-Frías, M. T., Madrid-López, E. J. (2019) Propiedades psicométricas de un instrumento para medir habilidades del pensamiento reflexivo en estudiantado universitario. *Revista Electrónica Educare (Educare Electronic Journal)* EISSN: 1409-4258 Vol. 23(3) SETIEMBRE-DICIEMBRE, 2019:1-13. doi: http://dx.doi.org/10.15359/ree.23-3.16. URL: http://www.una.ac.cr/educare.

González-Moreno, C. X. (2012). Formación del pensamiento reflexivo en estudiantes universitarios. *Magis, Revista Internacional de Investigación en Educación, 4* (9), 595-617.

Gravini Donado, M. L., & Iriarte Diazgranados, F. (2008). Procesos metacognitivos de estudiantes con diferentes estilos de aprendizaje. *Psicología desde el Caribe*, (22), 1-24

Hernández, S., R., Fernández, C., C. y Baptista, L. M. (2014) *Metodología de la investigación*. McGrawHill. https://apiperiodico.jalisco.gob.mx/api/sites/periodicooficial.jalisco.gob.mx/files/metodologia_de_la_investigacion_-_roberto_hernandez_sampieri.pdf.

Laisequilla R. y Margarita E. (2018) Pensamiento reflexivo para el desarrollo y perfeccionamiento de habilidades superiores de pensamiento. *Revista Internacional de Educación y Aprendizaje, 6*(3), ISSN 2255-453X. Global Knowledge Academics. Fundación Universitaria Iberoamericana, Universidad Internacional Iberoamericana. http://journals.epistemopolis.org/index.php/ educación.

Moguel, L., M. (2003) *Aprendizaje organizacional: Naturaleza, evolución y perspectivas. Estudio de caso en cuatro organizaciones en México*. Universidad Autónoma Metropolitana unidad Iztapalapa, Tesis doctoral. https://www.eumed.net/tesis-doctorales/2011/mjml/indice.htm.

Piaget, J. (1991) *Seis estudios de psicología*. Labor. http://dinterrondonia2010.pbworks.com/f/Jean_Piaget_Seis_estudios_de_Psicologia.pdf.

Rojas S., R. (2013) *Guía para realizar investigaciones sociales*. Plaza y Valdez. https://raulrojassoriano.com/cuallitlanezi/wpcontent/themes/raulrojassoriano/assets/libros/Antologia-Libros-Raul-Rojas-Soriano.pdf.

Ruffinelli, A. (2017) Formación de docentes reflexivos: un enfoque en construcción y disputa. *Educ. Pesqui., São Paulo*, v. 43, n. 1, p. 97-111, jan./mar. 2017. http://dx.doi.org/10.1590/S1517-9702201701158626. Universidad Alberto Hurtado, Santiago, Chile.

Webster, A. (2000) *Estadística aplicada a los negocios y la economía*. McGraw Hill. Https://dennismontes2.files.wordpress.com/2014/11/estadistica_negocios.pdf.

A C A D E M I C

P A P E R

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Use of forearm-hand casts in Colles fractures with conservative management: A literature review

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The World Health Organization (WHO) estimates that 12% of fractures caused mainly by falls and traffic accidents lead to disabilities that can end potential productive years of life. Credit for the description of the most common fracture model affecting the distal end of the radius is attributed to Sir Abraham Colles, who first described the fracture in 1814, and it has since been named after him (Enseñat, 2021). Colles fracture, also called Colles-Pouteau fracture, is a fracture that occurs in the radius less than 2,5 cm from the wrist. It is one of the most frequent fractures, especially in women over 60 who may also suffer from osteoporosis (Romero, 2009).

The incidence of fractures is multifactorial and almost always complicated by factors such as age, gender, comorbidities, lifestyle, and occupation. The factors that directly influence the occurrence of a fracture are external forces that are directly or indirectly applied and exceed the point of rupture of bone tissue; the risk factors that directly influence are: a) bone quality, b) age, and c) lifestyle (Domínguez, 2017). It has been observed that the male gender fractures at younger ages (17-49 years) and women at older ages, on average, after the age of 50 (López, 2022). Another factor to consider is osteoporosis, which is a systemic skeletal disease characterized by low bone density and a deterioration of the microarchitecture of bone tissue, with the consequent increase in fragility and susceptibility to the appearance of fractures. This disease most often affects postmenopausal women, in a woman/man ratio that can vary between 3 and 8 women for each man. Pointing to an incidence of 25% for women over 45 and 50% for women over 60 (Contreras, 2001). These types of fractures are more likely to occur during sports, and the risk increases if the patient has osteoporosis (Hermoso, 2003).

The mechanism of production is usually indirect and is produced by a fall in extension or dorsiflexion of the hand. The resulting deformity is known as “humpback” and is sometimes accompanied by avulsion of the ulnar styloid process. If the fall occurs on the back of the hand, that is, in palmar flexion, it is called an inverted Colles fracture or Smith fracture, and the resulting deformity is a "garden shovel" or "scythe", and it can be seen how the ulnar styloid protrudes dorsally (Serrano, 2008).

In the management of Colles fracture, supination greatly improves anatomical and functional results, prevents its most frequent complications, and plays an important role in maintaining the reduction, especially in patients with marked osteoporosis or obliquity of the fracture line (Delgado, 1998).

According to the time of initial treatment, 26.5% receive it within the first six hours, 70% after six hours and up to three weeks, while 3.5% after three weeks of the origin of the injury. This is reported by a study in open fractures in adults treated in a hospital in Latin America (Shiraishi, 2019).

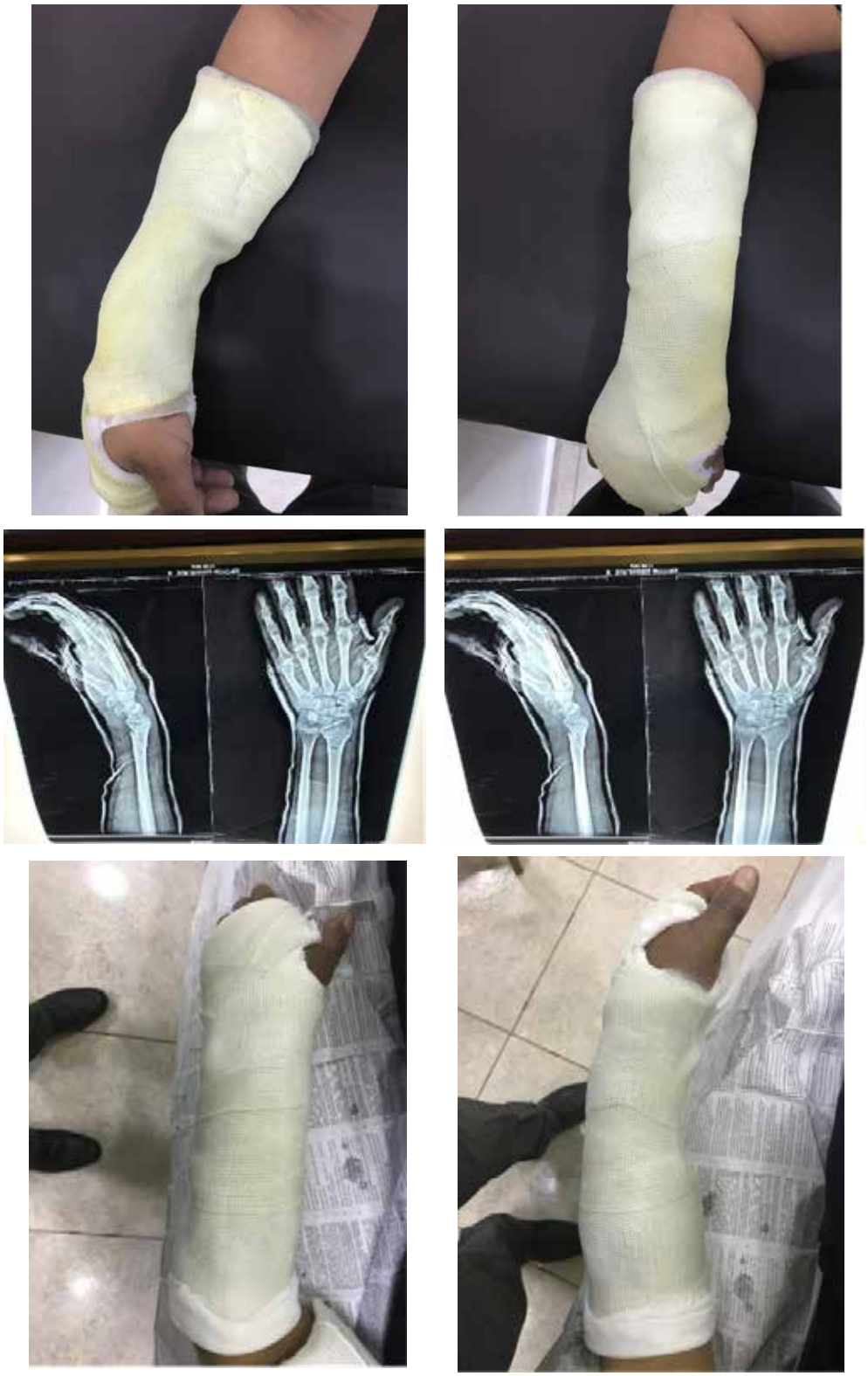
Frykman classifies wrist fractures according to whether they are intra-articular or extra-articular, and whether or not there is a fracture of the distal extremity of the ulna. It establishes eight different types of fractures (Table 1).

Table 1.
Types of Colles fractures according to location

Type	Descriptor
I:	Extra-articular distal radius fracture
II:	Extra-articular distal radius fracture + Distal ulna fracture
III:	Intra-articular radiocarpal fracture of the distal radius
IV:	Intra-articular radiocarpal fracture of the distal radius + Fracture of the distal ulna
V:	Intra-articular distal radius fracture
VI:	Intra-articular distal radius fracture + Distal ulna fracture
VII:	Intra-articular distal radius fracture involving the radiocarpal and radioulnar joints.
VIII:	Fractura de radio distal intraarticular radiocarpiana y radiocubital + Fractura del cúbito distal

Note: Enseñat, 2021.

The **diagnosis** of Colles fractures is generally made clinically: pain, deformity, swelling, and radiographic tests (Lutza, 2004). Figure 1 shows the forearm-hand cast in a Colles fracture with conservative management.



Note: Photographs taken by the author with the patient's permission.

Figure 1. Colles' fracture of the distal forearm.

In a high percentage of Colles fractures, the reduction achieved is lost shortly thereafter, which is attributed to the progressive reduction of edema, loosening of the cast, and free movement of the elbow and hand. However, until now, the deforming role of muscles has not been considered, despite being a fundamental element that must be taken into account in the pathophysiology and therapeutic aspects of any fracture (Delgado, 1998). Therefore, it can be considered that the use of brachial and below-elbow casts has advantages and also some disadvantages for this type of fracture (Table 2).

Table 2

Advantages and disadvantages of using a brachial cast vs. a below-elbow cast in Colles fractures

Joint/limb	Arm	Forearm
Hand	1. Severe swelling of the hand	1. Minimal swelling of the hand
	2. Severe functional limitation of the hand	2. Improved finger mobility
Elbow	3. Immobilized elbow	3. Elbow without a cast, so mobilization can begin immediately.
		4. The hematoma from the fracture extends to the elbow, and without a cast, it spreads quickly.
Shoulder	4. Double the weight of the plaster cast, limiting shoulder movement	5. Lower weight, allowing the patient to begin early mobilization of the shoulder.
		6. Greater comfort reported by patients due to lower weight and increased agility.
		7. It is easier to get comfortable resting and sleeping.

Note: Prepared internally based on evidence reported by 50 patients over 5 years.

The objective of this study is to analyze the advantages of using a forearm-hand cast in Colles' fractures treated conservatively. Regarding methodology, the study was based on five years of experience treating 50 patients who came in for diagnosis and conservative management.

CONCLUSIONS

Based on a review of the literature and personal experience, it can be observed that in the past, it was thought that Colles' fracture should be treated using a below-elbow cast to prevent pronosupination and displacement of the fracture. However, over time and through various studies, it has been observed that the same radiographic results are obtained with a forearm-hand cast once the fracture has been properly reduced.

Therefore, although similar results are obtained in both cases, a determining factor in successful recovery is the immediate rehabilitation of Colles fractures with the application of a cast that leaves the joints free, thereby shortening recovery time and leading to greater patient satisfaction.

REFERENCES

Contreras y Cols., (2001). *Osteoporosis: Factores de Riesgo, Prevención y Tratamiento Archivos Venezolanos de Farmacología y Terapéutica,* Volumen 20 - Número 1, 2001 (27-37) https://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0798-02642001000100003

Delgado Rifá E, Escalona Zaldívar R. (1998). *Ventajas de la supinación en la fractura de Colles. Revista Cubana de Ortopedia y Traumatología, 12* (1-2), 52-56. Recuperado en 06 de noviembre de 2024, de http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0864-215X1998000100009&lng=es&tlng=es.

Domínguez Gasca Luis Gerardo, Orozco Villaseñor Sergio Luis, (2017). Frecuencia y tipos de fracturas clasificadas por la Asociación para el Estudio de la Osteosíntesis en el Hospital General de León durante un año. *Acta Médica Grupo Ángeles.* Volumen 15, No. 4, octubre-diciembre 2017. Https://www.scielo.org.mx/pdf/amga/v15n4/1870-7203-amga-15-04-275.pdf

Enseñat Rojas JM, Díaz de la Rosa C, Cabrera Barbón JC, Jerez Labrada JA. (2021) Caracterización de pacientes tratados con minifijador externo RALCA por fracturas inestables del extremo distal del radio. Revista estudiantil 60 (280): e1204: http://www.rev16deabril.sld.cu/index.php/16_4/article/view/1204

Fisioterapia para mayores a domicilio (2024). *Fractura de Colles. Tratamiento Fisioterápico.* Https://fisiomayores.com/fisioterapia-tratamientos/fractura-de-colles/

Hermoso de Mendoza, M.T.. (2003). Clasificación de la osteoporosis: Factores de riesgo. Clínica y diagnóstico diferencial. *Anales del Sistema Sanitario de Navarra, 26* (Supl. 3), 29-52. Recuperado en 06 de noviembre de 2024, de http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1137-66272003000600004&lng=es&tlng=es.

López y Cols., (2022). Prevalencia de fracturas en adultos mayores Hospital *Angeles Mocel Acta Med GA. 2022; 20* (3): 250-254. https://dx.doi.org/10.35366/105728

Lutza Martin, Markus Gablay Sigurd Pechlaneraa. (2004). Fracturas de Colles intraarticulares, reducción abierta, fijación interna y relleno del defecto con injerto corticoesponjoso autólogo. *Tec. Quir. Ortop. Traumatol. (ed. esp.)* Vol. 13 núm. 2, https://www.elsevier.es/es-revista-tecnicas-quirurgicas-ortopedia-traumatologia-41-pdf-13065077