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Systemic thinking and gender: an exploratory study of Mexican female university students

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The purpose of this article is to present the results of a study conducted on a population of students from two educational institutions in western Mexico. The intention is to identify how students perceive their level of systemic thinking, focusing primarily on women. Thus, this article seeks to identify differences not only on the basis of gender (men–women) but also on the basis of social status (public and private institutions). Methodologically, a descriptive statistical analysis was carried out with which it was possible to conclude that, although statistically significant differences between men and women are not identified, they are found between groups of women in public and private institutions. This article invites reflection on the need to study possible gender gaps from an intersectional perspective, which considers the differences between genders and the various dimensions and relations of women in their educational process.

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Introduction

Systemic thinking is the ability of people to understand and analyze in an orderly manner how different elements, factors, or people interact in a given situation, environment, or problem; it is a determining skill when making a decision or facing a dilemma or challenging situation (Abuabara et al., 2023). Systemic thinking is a skill that involves perceiving elements as interconnected components of a larger system, seeing an entity as a well-organized structure, where the parts are interdependent and influence each other. Therefore, gaining a comprehensive understanding of the entire system is only achievable through a thorough comprehension of its individual components and how they interact with one another (Brown, 2019).

In recent decades, systemic thinking has taken on particular relevance in professional training. Within the theory of decision-making, it is considered that if at the time of solving a problem, there is no systemic vision of it, there is a risk of attending to isolated or insignificant causes (Khammarnia et al., 2017). The system could be temporarily improved, but the root cause of the problem is not addressed. The ability to see the totality is characteristic of systemic thinking, enabling the individual to appreciate the structures that comprise a complex situation and make more meaningful, lasting, and comprehensive decisions (Abuabara et al., 2023).

In this sense, educational institutions see complex thinking as an essential competency to acquire and develop in their students, a necessary element for professionals in an uncertain and complex world. However, the efforts made by universities to develop this type of high-level competencies may vary, since not all of them have human resources specialized in competency training or even have curricular programs more focused on technical and disciplinary development. In countries such as Mexico, there is a clear educational gap between the education provided by public and private universities, which is an important element to be considered when talking about lifelong learning skills training.

In this sense, will the level of development be equal between men and women or between institutions? What is the perception of achievement with which students conceive themselves? Will it vary by gender or type of institution?

Thus, this article presents the results of a study conducted on a population of students from two educational institutions in western Mexico. The intention is to identify how students perceive their level of systemic thinking, focusing primarily on women, to identify possible gender gaps that could occur within the training processes of both institutions. Thus, this article seeks to identify differences not only on the basis of gender (men–women) but also on the basis of the social status of the educational institutions (public and private institutions). The decision to focus on this competency assumed that systemic thinking is an important skill for lifelong professional training and, therefore, an element that can lead to reducing inequalities in the Latin American professional environment.

It is important to note that the present study measures the perception of achievement and not the development of competence, which responds to the relevance of perceiving oneself as competent at the time of professional training. If the student achieves the competency but does not perceive himself as a competent individual, he may be biased in his application in his professional life, as he feels that he is not skilled and therefore does not have the ability to deal with problems associated with that competency. In this sense, the present study pays special attention to perception, since it is directly associated with the process of decision-making and problem-solving.

The objective of contrasting public and private institutions is associated with the significant differences that exist between the training provided by these types of institutions, especially in

regions with high inequality gaps such as Latin America. Methodologically, we performed a descriptive statistical analysis of measures of central tendency, determining means and standard deviations and creating violin plots and boxplots. A *t*-test analysis was also carried out to determine whether the difference between means was significant.

Theoretical framework

Systemic thinking as part of complex thinking. Today, vocational training and the development of competencies for life require a multidimensional understanding of human, social, scientific, technological, and environmental conditions. When considering the interconnections of life (at the micro and macro system level), one can perceive the vast network of interdependencies, complementary associations, and connections that comprise life (Collado, 2016; Collado et al., 2018), itself a system of complexities.

Therefore, in the face of a complex world, it is necessary to consider training in proportional competencies, which allow individuals to develop an integrated vision of the environment through superior cognitive skills (Vázquez-Parra et al., 2023). In this sense, a competence that has been proving very valuable is complex thinking, which refers to the ability to understand and analyze reality based on the recognition of its interconnections and interdependencies from a critical approach, the adoption of objective methods and a creative vision (Baena et al., 2022).

For Morin (1990), complex thinking is a cognitive approach that recognizes and addresses the complexity inherent in the phenomena and systems of an equally complex world, considering an integrated perspective that avoids the fragmentation of knowledge. For this French philosopher (cited by Tomás and Murga, 2020), complex thinking is an ability that avoids the reductionist decomposition of problems, which, in the long run, although it considers the elements, does not perceive the interactions between them, giving way to limited knowledge of reality. Unlike other types of systems analysis, Morin's perspective focuses on the relevance of integrated analysis, appreciating not only the parts that comprise a system but also their interconnection and the way in which some elements influence others, perceiving reality as a situation that goes beyond the sum of its parts.

Under Morin's complexity approach, training for life and throughout life implicitly means developing competencies that allow people to function correctly, which, from a systemic approach, entails holistic behavior that integrates interdisciplinary cooperation to build bridges connecting vision, interrelationships, and interdependence of phenomena, events, and problems (Bricage, 2017). Complex thinking, as a formative competency, is comprised of four derived sub-competencies, which provide the individual with the ability to broaden his or her vision of the world and the problems he or she faces. These sub-competencies are scientific thinking, critical thinking, innovative thinking, and systemic thinking (Silva et al., 2020).

It is important to note that, although these sub-competencies are complementary, each one provides individuals with their own cognitive opportunities, as is the case with systems thinking, which allows them to appreciate their environment in a broad, integrated, and interconnected way, overcoming a linear and isolated view of their reality. In this sense, unlike the first three, systemic thinking is the sub-competency that provides greater skills for individuals to relate to their environment, as it allows them to observe, know, and understand the world, as well as to explain the complex dynamics of social life (Arbeláez, 2016).

Systemic thinking and its relationship to lifelong learning.

According to Edgar Morin (1990), Systemic Thinking is an approach to thinking that allows understanding the comprehensiveness inherent to systems, whether natural or social, in an integrated manner, i.e., avoiding reductionist analyses that break down systems into their elements, failing to see the interconnections and interactions inherent to the system itself. In this sense, Systemic Thinking promotes feedback and systems cycles, recognizing how an action can influence other elements, leading to non-linear and often unpredictable results (Abuabara et al., 2023).

For Morin (cited by Tomás and Murga, 2020), each part of the system contains information about the whole system, so that even if it is fragmented, it still represents the integrality. In this sense, it is necessary that individuals develop cognitive skills that allow them to develop this appreciation of the environment, as this will enable them to address complex problems and challenges in this interconnected and rapidly changing world (Bricage, 2017).

In this sense, it is important to note that systemic thinking is an approach to thinking that seeks to understand the complexity of systems and the environment, paying attention to the interconnections and interdependence of its components, in order to recognize that systems cannot be fully understood through reductionist visions of their parts (Khammarnia et al., 2017; Khammarnia et al., 2017). This is one of the central points that differentiate it from systematic thinking, which focuses on the application of organized systems, procedures, and methods that allow a problem to be approached in a methodical and orderly manner, i.e., breaking down the problem into small parts and approaching each part separately and sequentially (Rivlin, 2015; Rivlin, 2015). Although Systematic Thinking and Systemic Thinking can be confused, they are contradictory perceptions in the approach to complex problems, since while one seeks to decompose the problem (Systematic), the other seeks to understand it in an integrated manner (Systemic). In this sense, although the value of systemic thinking is recognized, this study, having Morin's proposal of complex thinking as its basis, adopts the need for an integrated approach to the environment, that is, the relevance of the acquisition and development of systemic thinking.

Under this line of reflection, it can be stated that at the professional level, Systemic Thinking is highly valued, since it allows to address complex problems that involve multiple variables and interactions, providing proposals that consider all the parts and their relationships. In this same sense, the individual who has developed his or her systematic thinking can make more informed decisions, considering how these affect different parts of the system (Vázquez-Parra et al., 2022; Vázquez-Parra et al., 2022). At the leadership level, Systemic Thinking is suggested as a necessary tool for the management of organizations, since this cognitive ability allows understanding how certain choices or decisions of the company can influence or affect employees, processes, and results in general, being able to improve processes, identifying inefficiencies and relationships with other processes (Baena et al., 2022; Baena et al., 2022). Being a competence that promotes communication, by fostering the collaboration of the parts of a whole, Systemic Thinking is also a relevant element to foster interdisciplinary approaches and thus innovation, being fundamental for adaptation and flexibility in changing environments (Hester and Macg, 2017; Hester and Macg, 2017).

In this sense, it is possible to note why the acquisition of this subcompetence can be a determinant for the professional development and therefore, the economic participation of women, which becomes a point of shared responsibility with the educational institutions. In conclusion, there is a connection

between education and attention to contemporary problems, which have gender considerations.

Systemic thinking and its relevance to the development of female professionals

The development of academic skills in women is intricately connected to the historical gender disparity, highlighting the gradual integration of women into higher education. As per the World Economic Forum's 2020 report, the gender gap in education is at 96.1%, making it the third-ranking dimension among those examined by the forum (WEF, 2020).

According to UNESCO (2021), "over time, women reached the education levels of men and progressively achieved higher levels of schooling than men" (p. 14). According to Williams and Wolniak (2021), higher education training and the success achieved by women could trigger one of the most important social changes in history, especially if the presence of women in traditionally male careers increases and those cease to be an eminently male space (Guzmán, 2016).

Women's professional training is linked to access to greater well-being over time (Eker and Ilmola, 2020), requiring systemic competency comprising current well-being and the interrelationships between knowledge and skills, experience, values, and norms and health (p.7-8).

Women's college competencies are relevant because they empower them with a configuration to prepare them for the future, influenced by demographic changes, social and cultural norms, technological innovation, and environmental changes. Such a future is inclined towards transformation through systemic competencies that can evolve personally and socially (Dlouhá et al., 2019). The training in these competencies is also oriented towards the formation of human capital considering the global guidelines for education, internationalization, and the ability to compete both in their university training and the labor market; therefore, the competencies must nod to learning activities with a practical orientation (Cejas et al., 2019).

If systemic thinking broadens perspectives to address complex problems, and understanding the interrelationships and interdependence of factors, it also can facilitate women's understanding of the web of relationships, obstacles, and challenges. They experience these due to subjective (Guzmán, 2016), heteronormative, and institutional factors that limit their full development (Nizam et al., 2018). They must move beyond what is known as the glass ceiling (Gallegos and Matus, 2018) and the sticky floor that perpetuates the (subjective) importance and exclusive dedication of women to the domestic sphere (Ramos et al., 2022).

As such, systemic thinking emphasizes multidimensional and relational contexts and the possibility of intertwining the conditions of women in the biological, anthropological, cultural, environmental, professional, and creative (Castañeda, 2018) spheres; it is a complex and integrative vision of training women not only for professions but for life (Ferrada-Sullivan, 2017).

The educational gap between public and private universities in Latin America.

The educational gap between public and private universities in Latin America can be significant and stems from several factors that impact different aspects of their operation and academic work. First, private universities tend to have more financial resources than public universities, which allows them to invest in technology, infrastructure, laboratories, libraries, and high-quality faculty, which can improve the quality of education offered. In addition, private universities often tailor their curricula to focus on practical skills and employability of graduates, which gives them the opportunity to establish closer ties with business

and industry to provide internship and practicum opportunities to ease students' transition into the world of work (Gonzalez and Alvarez, 2019). This considers focusing more on the development of skills and competencies rather than solely on the acquisition of disciplinary knowledge (Peris et al., 2018).

On the other hand, private universities often have more flexibility to design and adjust their curricula according to the demands of the labor market and industry trends, which leads them to be more up-to-date in terms of content, technology, and graduate profile needs, as well as to offer a wider range of study programs, including those that are more aligned with the latest trends in the labor market (Altbach and Salmi, 2021).

Of course, these differences may vary by country and institution, as there are specific cases, such as central universities in countries like Mexico, where public universities have strong government support, which leads them to have better educational conditions than many public institutions (Castellanos and De Gunter, 2022). Public institutions such as the National Autonomous University of Mexico, the University of Guadalajara, or the Autonomous University of Nuevo Leon, are educational centers with considerable public funding that allows them to have internationally competitive research centers and high-level specialized human resources. In addition, because they are free universities, they provide a greater opportunity to be inclusive and diverse, which contributes to the development of more equitable social skills than is the case in private institutions (Ferreira et al., 2019). Of course, this is not the reality of most public universities, since except for the specific cases mentioned above, there are many public institutions that carry out their functions with minimal governmental support, which leads to deficient educational work and very precarious attention to their students.

In this sense, educational institutions in the region, whether public or private, cannot be generalized, and the quality of their academic staff and the attention provided in their classrooms may vary considerably. Thus, it is necessary to propose research to recognize if these differences have an influence at the formative level, considering that this can have a clear impact on the development of competencies and valuable skills for future professionals in the region.

Thus, this research explores possible differences in the perception of complex thinking competence between a public and a private university, which, although they cannot be generalized, may provide an indicative window for future explorations.

Methodology

Participants and procedure. A convenience sample of 838 students from two technological universities in western Mexico consisted of 411 students from a private institution and 427 from a public institution. Students were selected from all semesters and various disciplines with a balance between men and women from both institutions. The study was conducted in October 2022. A self-administered questionnaire was answered voluntarily by the students using Google Forms (Table 1).

Considering that this was a study involving people, the implementation was regulated and approved by the interdisciplinary research group R4C, with the technical support of the Writing Lab of the Institute for the Future of Education of the Tecnológico de Monterrey.

Instrument and data analysis. For this study, one instrument was applied:

- E-Complexity is a Likert scale-based questionnaire designed for the purpose of assessing students' perception of their degree of competence in complex thinking and its sub-competencies (Castillo-Martínez and Ramírez-

Table 1 Participant data by gender.

Private University					
Men		Women		Total	
<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
232	56%	179	44%	411	100
Public University					
Men		Women		Total	
<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
262	61%	165	39%	427	100

Source: Own creation.

Montoya, 2022). In its entirety, E-Complexity consists of 25 statements that are answered on a five-level Likert scale, ranging from 1, meaning "Strongly Disagree," to 5, meaning "Strongly Agree" (Castillo-Martínez et al., 2022). The validation of this instrument included two stages: theoretical validation and content validation with the participation of experts. The theoretical validation was based on the analysis of instruments previously used to measure complex reasoning competence and its sub-competencies. This analysis revealed the lack of a comprehensive instrument, which led to the development of an instrument that combines complex reasoning with the four sub-competencies. On the other hand, content validation with experts was carried out to evaluate to what extent the questionnaire items adequately represent the content domain, considering three criteria: clarity, coherence, and relevance (Escoba and Cuervo, 2008). In terms of clarity, the mean score given by the experts was 3.31, equivalent to 82.7% on a scale of 1 to 4. As for coherence, the mean score was 3.38 (84.5%), and as for relevance, the mean score reached 3.54 (88.5%). Thus, all three criteria obtained scores above 60%, indicating a high level (3–4) and supporting the validity of the instrument with sufficient information to argue for its validity.

For data analysis, this study used a multivariate descriptive statistical analysis to describe how systemic thinking is acquired and developed, particularly in women, to identify gender gaps in professional training among the institutions studied. The statistical treatment of the data was carried out using the computational software R (R Core Team, 2017) and Rstudio (RStudio Team, 2022). The descriptive statistical analyses determined means and standard deviations and included boxplot analyses, violin plot analyses, and significance analyses on differences of mean values (i.e., *t*-tests).

Results

Table 2 shows the analysis of higher education students' perceived development of systemic thinking (using the means and standard deviations) by public and private universities and gender. It shows that both men and women from private universities perceived themselves as having higher systemic thinking development than students from public universities. By gender, it is observed that in private universities, men perceived themselves higher in systemic thinking than their female peers (means of 4.34 and 4.26, respectively). On the other hand, in public universities, women had the higher mean in the perception of systemic thinking (4.07 vs. 4.06).

To complement Table 2, Fig. 1 shows the bar graph with the mean and standard deviation in students' perception of the development of systemic thinking in both institutions by gender.

The figure shows that males and females perceived themselves with similar mean values in developing systemic thinking (males 4.19 and females 4.17). Similarly, the standard deviations of both genders showed similar behavior (males 0.57 and females 0.55).

Table 3 shows the *t*-test analysis to test whether the difference in mean values of the perception in the development of systemic thinking by males and females from both institutions was significant (*p*-value of 0.05). The table results show no significant difference in the perception of students' systemic thinking development at the gender level.

On the other hand, Fig. 2 shows the violin graph analysis by gender of students and by type of institution. Students of both genders from the private university perceived having higher development than those from the private university. Likewise, the smoothed Kernel-type density histogram in Fig. 2 illustrates that the students of both genders from private universities presented a higher density in mean values of perceived development (above 4.0). Meanwhile, the smoothed histogram of public university students showed more distribution of mean values below 2.5 by men and women.

On the other hand, the results in Fig. 3 illustrate the women's perceived development of systemic thinking by type of university. Women attending private universities perceived themselves as having a higher development than women in public universities. In private universities, 50% of women's mean values for perceived systemic thinking were between 4.0 and 4.7. Meanwhile, in public universities, 50% of the women's mean values in the perception of the development of this competency in women were between 3.8 and 4.3. Likewise, in public universities, there was a more significant presence of women with a perception of the development of systemic thinking below 3.0.

Table 4 shows the results of the *t*-test analysis to determine whether the difference in the women's mean values from public and private universities concerning their perception of the development of systemic thinking was significant. The table shows a significant difference ($p < 0.05$) in the perception of the development of this competency among women from the different types of institutions.

Table 5 shows the mean values and standard deviations by age range to better understand women's perception of systemic thinking. The table shows that women aged 27 years and older perceived themselves as the most developed in systemic thinking (mean 4.22). On the other hand, women aged 23 to 26 years and older had the highest standard deviation (1.00) and the lowest mean value (4.01) in developing this competency.

Figure 4 illustrates the behavior by age ranges in the perception of systemic thinking among women. Generally, women perceive themselves better in developing this competency as they age. This is observed among women aged 15–18 and 27 and over, where the perception of developing this competency increases up to 4.7%.

Table 6 shows the results of the *t*-test analysis performed to determine whether there is a significant difference in the mean values of women's perception of the development of systemic thinking by age range. Table 6 indicates no significant difference ($p < 0.05$) in the mean values of the perception of the development of this competency.

Discussion of results

The first results are those associated with systemic thinking overall and for each institution. Table 2 shows that, in general, the sample of men and women had high results (above 4.00), reflecting a perception of considerable achievement in systemic thinking, i.e., the students perceived themselves as competent at the moment of identifying complex realities of challenges and problems they face. It is important to note that although the mean of men outperformed women, it was not statistically significant, which is possible to appreciate in Fig. 1 and Table 3, where a *t*-test has been carried out. Thus, the first finding of our sample is that there were no statistically significant differences between men and women.

However, to delve into the results, Table 2 presents the data by institution, allowing us to note two issues. First, the perception of systemic thinking achievement is considerably higher in the private institution than in the public one, which is perceptible in both men and women. This can be corroborated by Fig. 2, which, using a set of violin graphs, shows that not only are the means

Table 2 Systemic thinking: mean values and standard deviations by gender according to university type.

	Men		Women	
	Mean	SD	Mean	SD
Systemic thinking	4.19	0.57	4.17	0.55
Private University	4.34	0.46	4.26	0.49
Public University	4.06	0.62	4.07	0.59

Source: Created by the authors.

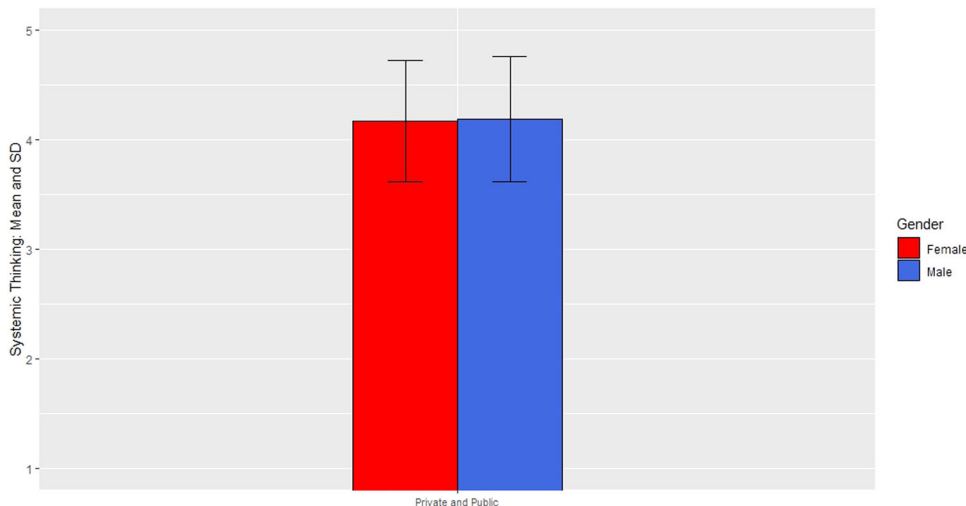


Fig. 1 Systemic thinking Bar chart: overall means and standard deviations by gender. Source: Created by the authors.

higher in the private institution but also a more marked concentration of positive results is reflected. In the private university, the concentration of responses falls between 4.00 and 5.00; in the public university, there is a significant presence of scores below 4.00. Second, contrasting the public and private universities, Table 2 shows a persistent gender gap in the private universities. Men show a considerable difference in the mean compared to their female peers. This is not present in the public university, which has a similar balance between both genders.

To adhere to the objective of this article, which was to have a more detailed description and a panorama of women’s reality

regarding systemic thinking, we decided to contrast the two groups of women. As seen in Table 2 and Fig. 3, women in private institutions had a higher perception of achievement than their peers from the public universities, which, as verified by the *t*-test analysis in Table 4, reflects a statistically significant difference.

From a critical point of view, intersectionality can contribute to understanding how women live, interact, and perceive achievement (Awid, 2004). This approach makes it possible to contemplate problems from an integral and systemic perspective, which, according to Bersezio et al., (2020), acts as an analytical strategy that provides new perspectives on social phenomena and facts (p. 4).

Notably, as shown in Fig. 3, one of the most marked differences between the two populations is due to the responses that deviate toward the lower ranges of the scale since, while the women at the private university have few scores below 3.00, public university women have many more below 3.00 extending to the lowest end of the scale. Thus, it would be relevant to analyze the learning process experienced by women in this to understand why some of them perceive themselves as highly competent, and others do not.

Considering the latter, we wanted to investigate possible factors affecting this group’s perception. One of the elements available was the age of the participants, which could be influential because

Table 3 Systemic thinking. t-test analysis. Difference of statistical significance between the perception of the development of systemic thinking in women and men. (p-value of 0.05).

	T	df	p-value
Gender	-0.550	750.21	0.5822

Source: Created by the authors.

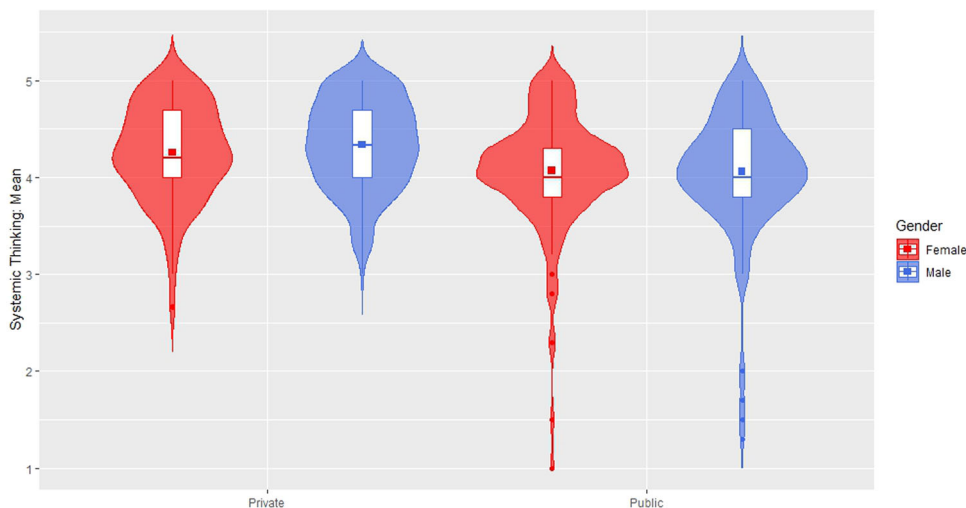


Fig. 2 Systemic thinking: Violin plot of perception in the development of systemic thinking by gender according to university type. Source: Created by the authors.

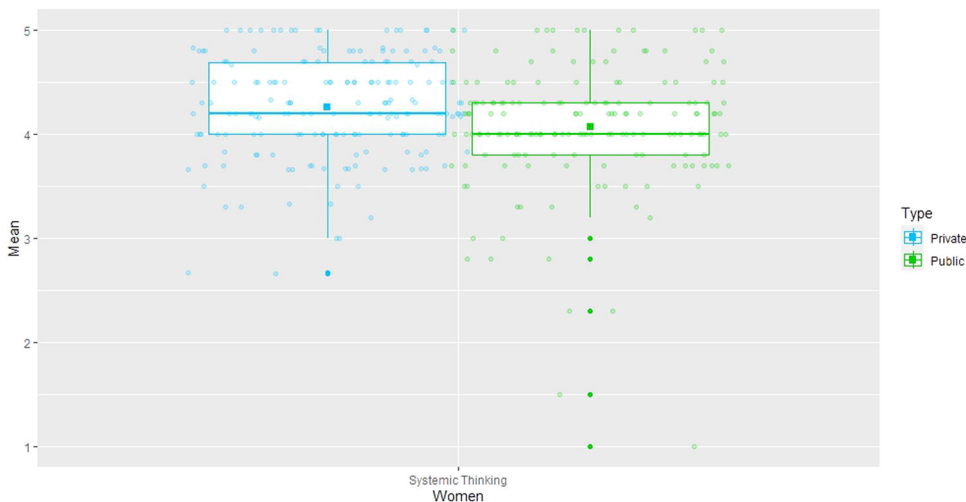


Fig. 3 Systemic thinking: Boxplot analysis of women's perceived development of systemic thinking by university type. Source: Created by the authors.

it is associated with their level of educational development. Thus, Table 5 presents the means of the women in the public university per their age ranges, showing that the variation of the means in the first three age groups is practically nil. In these age ranges, the group from 23 to 26 years of age had a very high segregation of responses, which may be the age group that represents the atypical responses at the bottom of the scale shown in Fig. 3. This can be corroborated in Fig. 4's scatter plot, which allows us to appreciate this trend in the results.

Some professors at this public university suggested that an impacting element that could have increased the means in the oldest age group could be the labor contact; usually, students over 27 years old and at the end of their formative process are already working. This broad vision of their environment and profession could be a trigger to increase their perceived achievement in systemic thinking, which is decisive when facing challenges and solving professional problems.

Considering this difference, we wanted to explore the reliability of this gap, which, according to the *t*-test in Table 6, is not

statistically significant in any of the groups. Thus, although Fig. 4 shows apparent differences between the first three groups and the oldest, these differences are not statistically significant.

Unfortunately, considering these last data, this study did not identify what could affect the perception of the women in the public institution in contrast to their colleagues in the private institution, opening the possibility of more specific studies in this sample population.

In conclusion, it is possible to reach the following findings.

- a. There is no statistically significant difference between men and women in their perception of achievement of the systemic thinking competency. That is, both genders perceived themselves as equally competent.
- b. Looking at the two populations, we see a difference between the perception of achievement by the public and private university groups, which, in the case of women, does yield a statistically significant difference.
- c. Delving deeper into this difference, we determined that the public university group presented a considerable deviation in responses, which could be argued to connect to the large number of age groups considered in the sample. Although differences were found in the means by age group, it was corroborated that age is not a determining factor since, despite the different averages, these differences were not statistically significant.

Based on these conclusions, it is relevant to point out previous studies that have already framed the presence of gaps of different types between public and private universities, such as the contributions of Akmaliah et al. (2013), Bayraktar, Tatoglu and Zaim with their study conducted in Turkey (2013), Mazumder (2014) who made a comparative between public and private institutions in the United States and Bangladesh, and Olaleye, Ukpabi and Mogaji (Olaleye et al., 2020) who describe these differences in public and private universities in Nigeria. However, none of the studies investigated have been conducted in Latin America, and none have focused on the measurement of competencies such as systemic thinking, which allows us to point out that there is an interest in these possible gaps between institutions, and that the results of this study, although not exhaustive, are valuable to initiate this discussion in the Latin American region.

Complementary to this, these results identify the need for future studies to include the perspective of intersectionality to recognize the diversity of relationships, factors, or environments

Table 4 Systemic thinking. t-test analysis. Statistical significance difference of women's perceived systemic thinking competency in public and private universities (p-value of 0.05).

	t	Df	p-value
Women (Public and Private Universities)	3.207	318.51	0.00147

Source: Created by the authors.

Table 5 Systemic thinking: analysis of mean and standard deviation by age ranges in women's perceived development of systemic thinking.

Age	Mean	SD
15-18	4.03	0.61
19-22	4.05	0.53
23-26	4.01	1.00
27 and older	4.22	0.58

Source: Created by the authors.

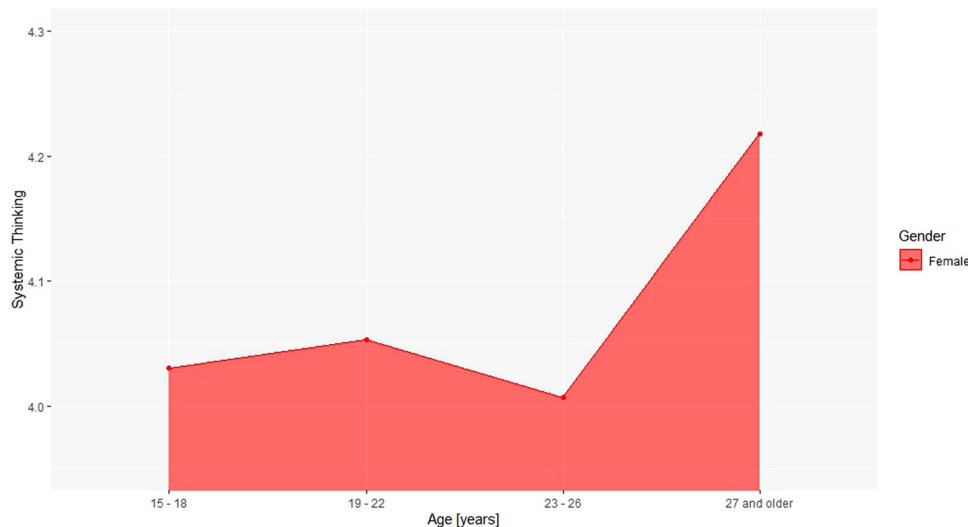


Fig. 4 Systemic thinking: Mean values in the perception of the development of systemic thinking by age range of females.

Table 6 Systemic thinking. t-test analysis.
Statistical significance difference between the perceptions of the development of systemic thinking in women by age (p-value <= 0.05).

Pr(>F)	15-18	19-22	23-26	27 and older
15-18	1.00	-	-	-
19-22	0.64	1.00	-	-
23-26	0.94	0.78	1.00	-
27 and older	0.36	0.19	0.42	1.00

Source: Created by the authors.

that may interfere in the perception of women's achievements related to systems thinking, as an additional element to consider among students from public and private institutions.

Conclusions

The purpose of this article was to present the results of a study conducted on a population of students from two educational institutions in western Mexico. The intention was to identify the level of perception with which a group of students conceives of their level of systemic thinking, focusing primarily on women, to identify possible gender gaps that could occur within the training processes of both institutions. Thus, this article seeks to identify differences not only on the basis of gender (men-women), but also on the basis of social status (public and private institutions).

After analyzing the results, we conclude that no statistically significant differences by gender can be identified. However, it was possible to find statistically significant differences by institution of study. In this sense, women from private institutions were those who perceived a greater development of systemic thinking competence, compared to women from public institutions, who not only had a lower perception but also a considerable dispersion in their answers, since some participants perceived themselves as very competent and others as incompetent.

Unfortunately, although we sought to delve deeper into this identified situation, this study was limited by the lack of demographic data collected from the participants since, being an exploratory study, the ethics committee responsible restricted the information that could be collected by the instruments. Thus, although an attempt was made to better understand what happens in the public institution that triggers this difference in the responses of its population, it was not possible to identify a key element.

Thus, a limitation of this work is that its exploratory results cannot be considered exhaustive. However, the data and analyses presented, and the areas of opportunity suggested by the results mean that the work has value. In a practical sense, this research has pedagogical value because it invites educational institutions to evaluate how these competencies are formed and validate whether the training process is equitable for the entire population. On the other hand, being a study focused on women, it also has gender implications since, although no significant differences were found between men and women, there were significant differences between both groups of women, a gap that should be analyzed from an intersectional perspective.

Although the results seem limited, they shed light on a possible area of opportunity for future studies that focus exclusively on female students at public universities, seeking to understand the reason for this gap in their perception of achievement. It is essential to consider that students' systemic thinking is a determining ability to measure how the environment is perceived when facing a challenge or solving a problem. The fact that some students perceive themselves as competent and others do not is an issue that must be addressed as part of the responsibility of

every institution to achieve equitable competency development in all its students.

In conclusion, this study allows us to appreciate the value of systemic thinking in the process of approaching and managing complex problems in the world, which has gender implications. Although more and more women are gaining access to education, it is necessary to ensure that they have an equally enriching training process as male students, since it is not enough to increase the number of women professionals, it is necessary to achieve formative equality. In this sense, paying attention to the development and perception of women's competencies is an element that not only favors education but also the possible reduction of the gender gap in today's world.

Data availability

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical reasons.

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Author contributions

Conceptualization, JCV-P, MC-A, and ARB; Methodology, JCV-P, MC-A, and ARB; Software, MC-S; Validation, MC-S; Formal analysis, JCV-P, MC-S, and ARB, Investigation, JCV-P, MC-A; Resources, JCV-P; Data curation, MC-S; Writing—original draft, JCV-P, MC-S; Writing—review & editing, JCV-P, MC-A, and ARB; Visualization, MC-S; Supervision, JCV-P, MC-S; Project administration, JCV-P; Funding acquisition, JCV-P. All authors have read and agreed to the published version of the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This study was regulated and approved by the interdisciplinary research group R4C, with the technical support of the Writing Lab of the Institute for the Future of Education of the Tecnológico de Monterrey. As well as by the institutional ethics committee: Approval code: 03000132. Approval date: 09/18/2022.

Informed consent

All those involved in this study expressed their informed consent to participate in it, and that their data were used for research purposes, adhering to the terms and conditions and privacy notice of the institution: <https://tec.mx/es/aviso-de-privacidad-sel4c>.

Additional information

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