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Complex thinking and its relationship with gender and age in a group of Mexican students☆

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ABSTRACT

The literature addresses the importance of developing competencies, but not from the complexity theory, nor does it show the importance of the correlation between gender and age in this process. This article aims to show the results of a study seeking a possible correlation between the perceived achievement of complex thinking competency and gender and age in a student population attending a technological university in western Mexico. The intention is to argue whether there is a statistically significant difference in the acquisition and development of this competency between men and women of different ages during their training. Methodologically, a multivariate descriptive statistical analysis was carried out to demonstrate the relationship between these indicators. We concluded that there is evidence of a gender gap in developing the perceived achievement of the complex thinking competency and its sub-competencies since neither in the overall result nor in the specific results by indicator did women achieve results proportional to those of their male peers, although, in most competencies, they initially surpassed them. The learning experience shows that the gender gap in perceived achievement of complex thinking competency widens as the student population advances in their training process.

1. Introduction

In today's complex and uncertain world, education is expected to constantly evolve; thus, among other priorities, it pays increasing attention to the flexible formation of competencies rather than the static acquisition of theoretical knowledge (Baena, Ramírez, Mazo,

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& López, 2022). However, the cognitive process that accompanies the development of competencies is not the same as the memorization of concepts, so it is increasingly common to find studies that analyze the various factors and elements that influence this new educational reality. In this sense, it is not strange that within the same class, one student develops a skill better than another, opening the need to consider as many indicators as possible (Vázquez-Parra, Castillo-Martínez, Ramírez-Montoya, & Millán, 2022).

Thus, the present article aims to present the results of a study conducted on a population of Mexican students to describe how age and gender can influence their perceived development of complex thinking competency and its sub-competencies. This competency is selected because it is a professionally valuable skill that provides an integrated vision of the environment and a greater capacity for problem-solving. This study is based on the academic need to identify possible variables that have an impact on the competency and skills training processes within educational institutions, as well as on professional demands, and to find out possible reasons that influence the labor gender gap that exists in regions such as Latin America. Although, as will be pointed out in the theoretical framework, there are previous studies that argue the differences in the formative processes between men and women, there are few studies conducted in university populations, and even fewer that consider the possible relationship between the development of complex thinking and age. In this sense, the present study, although exploratory, sustains its relevance both for its possible theoretical contribution and its impact on the professional training of complex thinkers.

2. Theoretical framework

2.1. The importance of competencies in lifelong education

Education in the 21st century has changed dramatically from the previous century, with educational institutions recognizing that each learner has different knowledge, skills, attitudes, and values and, therefore, may learn differently. According to the OECD (2019), curricula must allow for non-linear learning trajectories rather than expecting all students to follow a linear progression along a single, standardized path. The OECD (2019) defines a competency as more than "skills" because skills are the prerequisite for acquiring a competency. In this sense, competency implies more than the mere acquisition of knowledge and skills; it means the mobilization of knowledge, skills, attitudes, and values to respond to complex demands in situations of uncertainty. Industry 4.0 increased the demand for a broader range of multifaceted, transdisciplinary, and integrated skills to address the challenges and seize the opportunities of the 21st century's rapidly changing contexts. UNESCO (2019) recognizes that competency-based curricula have gained momentum and, at the same time, notes that more and more countries are aligning curricula to the competency approach. The curriculum is the first operational tool to ensure the sustained relevance of the development of education and learning systems. A competency-based approach enables youth and adults to acquire the right tools to effectively leverage opportunities.

What is certain is that the Human Capital Index of the World Economic Forum (WEF, 2017) indicates that the countries of the European Bank for Reconstruction and Development (EBRD) have the highest levels of skills, while Latin America, the Caribbean, and Africa have the lowest skill levels. Thus, it is necessary to invest in human capital through education that articulates new digital, socioemotional, and high-level cognitive skills (including creative thinking, the ability to learn, and problem-solving) (World Bank, 2016; BID, 2017; AfDB, ADB, IDB, EBRD, 2018; McKinsey Global Institute, 2018). According to the Inter-American Development Bank, a person born in Latin America and the Caribbean will reach adulthood with fewer skills than a person born in the United States (IDB, 2017:78). Therefore, it is necessary to identify and strengthen the appropriate tools and instruments for students to be increasingly transversal, multidimensional, and equipped for planetary reality. Subsequently, initiatives that close the skills gaps must be initiated.

2.2. Age as an element that impacts psychoemotional development and the acquisition of skills

The transition from adolescence to adulthood implies that individuals are aware of the social phenomenon of which they are a part: they are cultural and social individuals, autonomous in relational and relative terms, products of a society, and endowed with a culture. The first monograph on the anthropology of education, written by Margaret Mead (1943), established that formal and informal education are critical sites of cultural acquisition that affect and shape the development of people's personality, intellect, and physical abilities. One of the most important rites is the transition from puberty to the adult world; contemporary society defines education and school as the initiation ritual that must be carried out to accompany adolescents in their access to other fields of social life. Higher education prepares students to acquire a university degree that will give them the necessary tools to enter the labor market in their adult life (Bourdieu, 2008). The anthropological perspective has contributed to notions about the sociocultural development of individuals and their acquisition of skills as a function of their age.

So, if education and educational institutions play an essential role in the transition from adolescence to adulthood, considering psychoemotional development and the acquisition of skills, the content taught in educational spaces must be adapted to what aligns with the individual's stage of life, noting the difference between childhood and adolescence, and between adolescence and adulthood. According to Morin (2020), education transforms information into knowledge and transforms knowledge into wisdom. In the university, adults must learn beyond disciplines and integrate: knowledge of the determinants and presuppositions of knowledge; rationality, scientism, objectivity; interpretation; argumentation; mathematical thinking; the relationship between the human world, the living world, the physical-chemical world, the cosmos itself; interdependence and communications between sciences; problems of complexity in different types of knowledge; the culture of humanities and scientific culture; literature and human sciences; science, ethics, politics, and so on (Morin, 2020:84–85).

2.3. Gender as an element related to the psycho-emotional-educational development of individuals

The presence of women in higher education has increased significantly in the last two decades. Currently, there are practically equal opportunities for access to the educational system between men and women. It is possible to observe a generation gap. Now the average educational level of young women is considerably higher than that of their mothers; therefore, their life projects are also different. So, "the generation gap forces young women to do their own projects, to elaborate their own ideas of the future, with very little support from previous models or traditions" (Beck and Beck-Gernsheim, 2012). However, sexism and gender discrimination are far from having disappeared in educational spaces (Hideg and Shen, 2019; Edwards et al., 2022; Yarrow and Davies, 2022). Educational institutions reinforce gender normative rules and behaviors, which are also reproduced in workspaces and generate differences in income, consistently lower for women, even if they have the same preparation as men. It has been studied that the increase of women or men in a given occupational group does not change the gender basis in educational or occupational identities (Conway et al., 2018; Lamas, 2018a; Lamas 2018b).

To better understand the gender approach in education, it is necessary to associate it with other social realities and relations categories, such as diversity and equity. Gender is related to diversity when essentialisms are overcome, and it is assumed that there are different cultures, traditions, and contexts. There are also different ways of being a man and a woman (Rebollo, 2010; Rodríguez and Iturmendi, 2013). Gender and equity make it possible to identify the cultural and social mechanisms and causes that determine and structure the inequality of opportunities and rights between men and women (Guthridge et al., 2022). Educational institutions have placed greater emphasis on imparting knowledge about diversity and gender equity, striving for gender inclusion, generating greater equality of opportunities and rights between men and women, and valuing the skills and competencies of all students. But gender gaps in education persist, such as the low school performance of male adolescents related to norms of masculinity that discourage the development of non-cognitive skills and the low participation rate in STEM studies of female adolescents associated with aspirations and social influence (Lundberg, 2020).

The gender gap in educational attainment between males and females has raised concerns that the skills development of teenage males is more susceptible to family disadvantages, poor-quality schools, and less-educated neighborhoods than adolescent females. Research in the United States showed that young women appear more resilient to father absence when the outcomes are adolescent school problems, suspensions, and educational aspirations. In contrast, young men appear more resilient to their father's absence when examining depression (Lei and Lunderberg, 2020). The authors concluded that adolescent behavior is related to the gender norms of parents, teachers, and the school environment. Young men tend to externalize their behavior in problematic ways, and young women tend to internalize it through anxiety and depression. Another research conducted with students in Australia reports that females have higher educational achievement than males due to gender differences in time invested (Nguyen et al., 2022). The authors argue that gender differences in time investment are quantitatively significant in explaining the female advantage in most cognitive and non-cognitive skills, which becomes more pronounced as young women transition to other life stages.

2.4. Complex thinking and its sub-competencies

Complex thinking aspires to non-partitioned, non-divided, non-reductionist, and non-unidimensional knowledge, i.e., it leads to multidimensional thinking that is interrelated, interacting, and interfering. Simultaneously, it recognizes the incompleteness of all knowledge (Morin, 2001). From this perspective, complex thinking is a cognitive tool that can expand people's thinking capacity when faced with challenging situations or problems; it can also develop competencies that allow them to think comprehensively about reality with a broad vision of the world (Vázquez-Parra et al., 2022).

This notion of complex thinking as an integrative cognitive ability implies that individuals develop 4 associated subcompetencies (Ramírez-Montoya et al. 2022):

- Systematic thinking: cognitive ability that facilitates the integral perception of phenomena, recognizing the interconnection of conforming elements, as well as their dynamics, interactions, and impact (Silva & Iturra, 2021).
- Scientific thinking: refers to the capacity developed by people to solve problems under the appropriation of objective, validated and standardized methods that consider the importance of palpable evidence to provide greater reliability to the results derived from their decisions (Suryansyah, Kastolani, & Somantri, 2021).
- Critical thinking: evaluates the soundness of one's own and others' reasoning to form one's own judgment in a situation or problem and the identification of false arguments (Cui et al., 2021).
- Innovative thinking: Refers to the ability to generate original and novel ideas, solutions or concepts. It is a way of thinking that goes beyond the conventional and traditional, allowing the exploration of new perspectives and approaches to address problems and challenges (Rodríguez-Abitia et al., 2022).

Higher education marks a stage of individual life. Entry constitutes a rite of separation for students. They are immersed in a marginal state, and the stage culminates with a ritual of incorporation into adult life and work responsibilities(Van Gennep, 2008). In contemporary Western society, higher education is a set of rites that prepares students to move on to another living situation, develop strategies to solve problems and take rich and less mutilating actions. The role of higher education institutions is to establish a method to facilitate the development of strategies for knowledge and action, helping students to transcend the state of disarticulation and the fragmentation of knowledge and social and political thought (Morin et al., 2003; Morin, 2014). An education aimed at developing and scaling complex thinking and its sub-competencies and influencing the students' perception of their achievement at this stage of their lives can help them mediate their ideas and reality, learn beyond disciplines, and disallow social and cultural stereotypes about gender and age, which are obstacles to achieving the goals they consider relevant in their profession.

3. Methodology

3.1. Participants and procedure

A convenience sample of 427 students in a technological university that had adopted a competency-based education model in western Mexico comprised 262 males and 165 females. Students from different disciplinary areas, semesters, and ages were included. The study was carried out in August 2022. A self-administered questionnaire answered through Google Forms was answered by the students voluntarily (Table 1).

In terms of age, the sample was classified into 4 age ranges: 15–18 years (54 students), 19–22 years (296 students), 23–26 years (44 students) and over 26 years (33 students). It is recognized that it was not possible to guarantee a balance between the age ranges, however, this responds to the most usual ages of university students. Despite the difference in the number of participants in each age range, there is a sufficient population in each category for the analyses to be representative for this exploratory study.

Considering this was an exploratory study involving individuals, 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 Tecnologico de Monterrey.

3.2. Instrument and data analysis

The eComplexity instrument aimed to measure the students' perceived mastery of the reasoning-for-complexity complexity and its sub-competencies. It is an instrument validated theoretically and statistically by a team of experts in the field. The validation was verified with 443 participants who demonstrated the reliability and internal consistency of the instrument. For this validation, the criteria of Clarity (3.31), Coherence (3.38), and Relevance (3.54) were considered, determining that the eComplexity instrument was highly valid and reliable (Castillo-Martínez et al., 2022). The device comprised 25 items divided into four sub-competencies: Systemic, scientific, critical, and innovative (or creative) thinking. Each item was answered on a 5-level Likert scale: Completely agree, agree, neither agree nor disagree, disagree, completely disagree (Table 2).

Methodologically, the study involved a multivariate descriptive statistical analysis intending to find patterns of students' perception in developing complex thinking considering gender and age. The descriptive statistical analysis of the data was carried out through the computational software R (R Core Team, 2017) and Rstudio (RStudio Team, 2022). For the descriptive statistical analysis, we mainly determined measures of central tendency complemented by graphs to facilitate their interpretation. Thus, the analyses calculated the means and standard deviations considering the variables of students' gender and age. We supplemented these with violin, boxplot, and scatter plot analyses of the data. Moreover, we conducted a Differential Item Functioning (DIF) test using the Mantel-Haenszel method (Raju et al., 1989; Uttaro & Millsap, 1994). The primary goal of this test is to determine if there is a systematic difference in the likelihood of answering a specific item correctly between different groups, after accounting for overall ability. To this end, we evaluated the 25 items of the instrument, differentiating between responses from men and women. In doing so, we aimed to identify if the challenges faced by one gender or the other are not due to differences in the ability that the questionnaire measures, but to factors directly related to gender.

We calculated the means of the students' perceived competency and sub-competencies of complex thinking to have a representative value for these in the sample. This was complemented by the calculations of standard deviations. The standard deviation is a measure that lets us know the dispersion or variation of the students' data from the mean. These analyses were graphically complemented with violin and boxplot analyses. Regarding the latter, the boxplot diagram and the smoothed histogram (i.e., density plot) are synergistically combined into a single visualization that reveals the internal structure of the data (Hintze & Nelson, 1998). On the other hand, the violin plot provides insight into the data clusters, peaks, valleys, distribution bumps, and Kernel-like probability density. On the other hand, the boxplot analysis (also known as a box and whiskers diagram) allows us to see four main characteristics of the students' perception: its center, its dispersion, its symmetry, and the outliers, in quartiles or percentiles (Williamson, 1989). Finally, a line and area graph illustrating students' perception by age group and gender in developing complex thinking competency was created (Tables 1 and 2).

Table 1
Participant data by gender.

Men		*Women*		*Total*	
n	%	*n*	%	*n*	%
262	61 %	165	39 %	427	100

Source: Own creation

Table 2
EComplexity instrument.

Sub-competencies	Item	Question
Systemic Thinking	1	I can find associations between a project's variables, conditions, and constraints.
	2	I identify data from my discipline and other areas contributing to solving problems.
	3	I participate in projects that need to be solved using inter/multidisciplinary perspectives.
	4	I organize information to solve problems.
	5	I enjoy learning different perspectives on a problem.
	6	I am inclined to use strategies to understand the parts and whole of a problem.
Scientific Thinking	7	I have the ability to identify the essential components of a problem to formulate a research question.
	8	I know the structure and formats for research reports used in my area or discipline.
	9	I identify the structure of a research article used in my area or discipline.
	10	I apply the appropriate analysis methodology to solve a research problem.
	11	I design research instruments consistent with the research method used.
	12	I formulate and test research hypotheses.
	13	I am inclined to use scientific data to analyze research problems.
Critical Thinking	14	I can critically analyze problems from different perspectives.
	15	I identify the rationale for my own and others' judgments to recognize false arguments.
	16	I self-evaluate the level of progress and achievement of my goals to make the necessary adjustments.
	17	I use reasoning based on scientific knowledge to make judgments about a problem.
	18	I make sure to review the ethical guidelines of the projects in which I participate.
	19	I appreciate criticism in the development of projects to improve them.
Innovative Thinking	20	I know the criteria to determine a problem.
	21	I have the ability to identify variables from various disciplines that can help answer questions.
	22	I apply innovative solutions to diverse problems.
	23	I solve problems by interpreting data from different disciplines.
	24	I analyze research problems considering the context to create solutions.
	25	I tend to evaluate the solutions to a problem with a critical and innovative sense.

Source: Own creation

4. Results

Table 3 shows the mean values of students' perceived development of complex thinking competency by gender and age. The results show the opposite behavior of men and women as age progresses. Among men, the lowest age group mean was 15–18 years old (3.75). Females in this age group had the highest mean (4.01). Both genders had similar mean values for perceived complex thinking at ages 19–22 and 23–26.

Fig. 1 is the violin plot analysis of the students' perception by age and gender, which makes it possible to highlight the probability density of the kernel-type distribution of their perception. We can observe that the distribution of the means of the females from 15 to 18 years of age is high (values greater than four). On the other hand, for males in the same age range, the distribution is concentrated in mean values of four and lower. The distribution density reveals the opposite behavior in older students. Here, males present a higher distribution density in mean values greater than four, while females' means are mainly concentrated in values of four.

On the other hand, Table 4 shows the analysis of the students' perception of the development of the sub-competencies of complex thinking by gender and age. Notably, men aged 27 years and older had the highest means in each sub-competency of complex thinking. It should also be noted that students of both genders perceived the least development in scientific thinking (especially students between 23 and 26 years of age). On the other hand, the highest mean value attained by both genders was in systemic thinking.

Fig. 2 presents the boxplot analysis of the students' perception of developing the sub-competencies of complex thinking by age and gender. It illustrates the data dispersion in each sub-competency, its symmetry, behavior by quartiles, and outliers (if any). Notably, female students between 15 and 18 years of age had the most dispersion; it occurred in the sub-competency of innovative thinking. In this same age range, women perceived themselves as higher in each sub-competency than men. Among students from 19 to 22 years of age, the behavior in perception is very similar for both genders; however, among men, there are more outliers in the lowest quartile in all sub-competencies in this age group.

For students between 23 and 26 years of age, the mean values of perceived development are very similar in all sub-competencies. Notably, women have high dispersion in systemic thinking, while men present more low mean values in systemic and scientific thinking. On the other hand, among students 27 years of age and older, the means show that females perceived themselves as less

Table 3
Complex thinking competency: Means and standard deviations by age and gender.

	Men		Women	
Age range	Mean	SD	Mean	SD
15–18	3.75	0.52	4.01	0.60
19–22	3.86	0.62	3.92	0.53
23–26	3.85	0.68	3.91	1.01
27 and older	4.40	0.54	3.96	0.66

Source: Created by the authors.

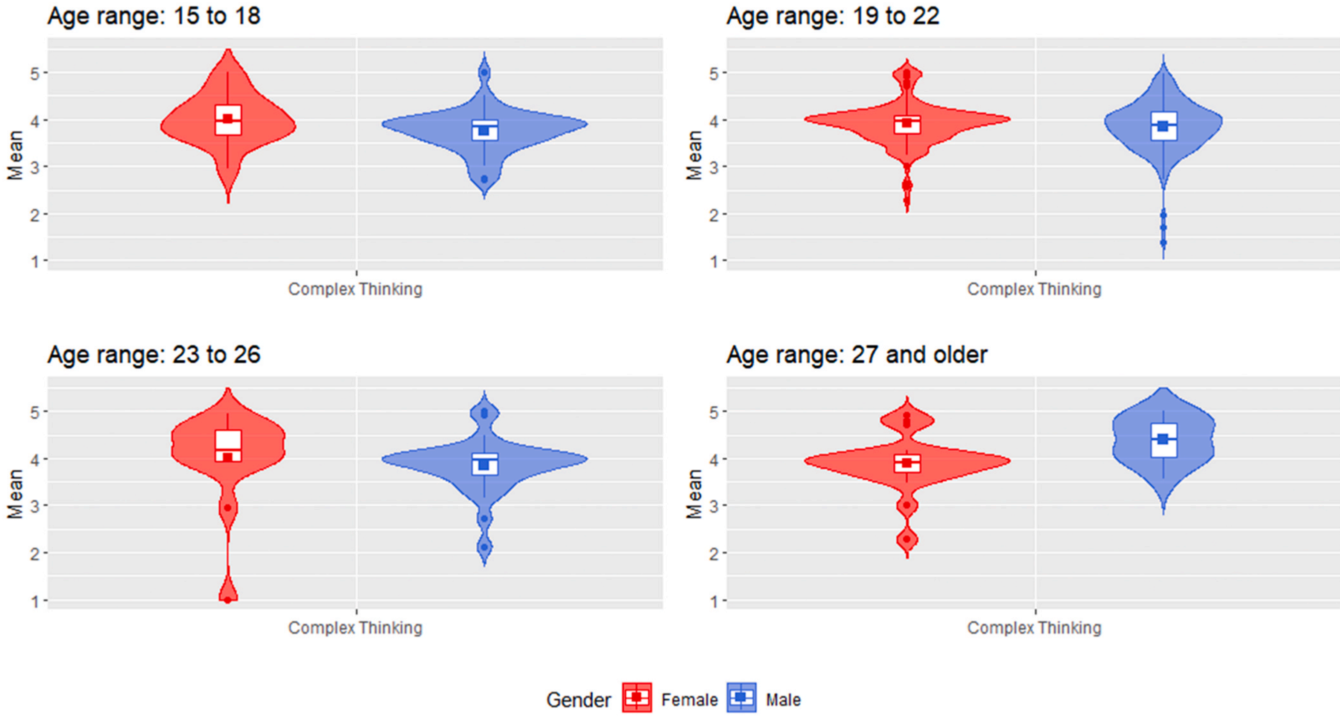

Fig. 1. Complex thinking competency. Violin plot. Analysis by age and gender. Source: Created by the authors.

Table 4
Complex thinking sub-competencies**:** Means and standard deviations by age and gender.

Sub-competency	Age	Men		Women	
		Mean	SD	Mean	SD
Scientific thinking	15–18	3.69	0.57	3.90	0.64
Scientific thinking	19–22	3.65	0.63	3.77	0.51
Scientific thinking	23–26	3.59	0.57	3.71	1.08
Scientific thinking	27 and +	4.21	0.65	3.78	0.73
Critical thinking	15–18	3.79	0.46	4.13	0.54
Critical thinking	19–22	3.92	0.58	3.97	0.54
Critical thinking	23–26	3.95	0.63	4.00	1.09
Critical thinking	27 and +	4.38	0.57	3.99	0.63
Innovative thinking	15–18	3.70	0.51	3.96	0.66
Innovative thinking	19–22	3.80	0.60	3.87	0.50
Innovative thinking	23–26	3.79	0.65	3.93	0.94
Innovative thinking	27 and +	4.36	0.51	3.86	0.64
Systemic thinking	15–18	3.80	0.55	4.04	0.60
Systemic thinking	19–22	4.08	0.60	4.05	0.53
Systemic thinking	23–26	4.09	0.76	4.01	1.00
Systemic thinking	27 and +	4.65	0.37	4.22	0.57

Source: Created by the authors.

developed than men in all the sub-competencies. Likewise, the lowest mean values in perception in each sub-competency correspond to female students.

Fig. 3 is a line and area plot of students' perception in developing overall complex thinking competency by age range and gender. In the figure, the gender gap in the perception of the development of complex thinking competency is evident, mainly in students aged 27 years and older. In this category, males' perceived development attained a mean close to 4.4, while the females' was 3.89, a significant difference of 0.5 in perceived mastery.

Table 5 shows the results of the Differential Item Functioning (DIF) test conducted using the Mantel-Haenszel method by gender. The results indicate that Item 13, related to scientific thinking (see Table 2), is where significant differences exist ($p \leq 0.05$). This suggests that there are differences between men and women in using scientific data to solve problems.

Likewise, Fig. 4 displays the graph of the Differential Item Functioning (DIF) test using the Mantel-Haenszel method with a significance level of 0.05. In this graph, it can be observed that Item 13 surpasses the detection threshold of the MH Chi-square statistic (3.84).

5. Discussion of results

The first data presented were the means of the overall complex thinking competency. Table 3 shows the general results by age group considering the gender variable. First, for men, a possible trend associates progressing age with progressively increasing means: the lowest mean was in the 15–18-year age group, and the highest was in the group over 27 years of age. Only the 23–26-year-old age group had a (very slight) decrease in mean.

Interestingly, the women had an opposite trend; the age group with the best results was the 15–18-year-old group, and the worst outcomes occurred among the 23–26-years-old. The oldest female students (over 27) had an upturn in the mean, but the overall trend in perceived complex thinking development among women decreased with age progression, contrary to the group of men.

Another relevant point in this table is that women had higher means than men in the first 3 age groups, but as their perceived achievement decreases with age, men approach matching them and then surpass them by a wide margin in the group over 27 years of age (M. 4.40 - W. 3.96). Thus, the lowest result is for men between 15 and 18 years of age (3.75), and the highest mean is also for men, but in the group over 27 years of age (4.40).

To better understand these results, we created four violin graphs (Fig. 1), one for each age range. As for men, the trend of improvement is graphically noticeable; in the first graph, it can be seen that the concentration is in the middle part of the violin (4.0), which is modified in the second age range, where the results between 4.5 and 5.0 are more noticeable. In the third graph, the men's results have a concentration at the top of the scale (5.0), which completely modifies the violin in the population over 27. Unlike the 15–18-year-olds, where the concentration of the violin was at 4.0, the over-27 violin is very considerable in responses of 5.0.

For the females, similar to Table 3, Fig. 1 shows the 15–18 age group with a marked concentration of 5.0 responses, which diffuses considerably in the 19–22 age group. Interestingly, the trend of positive responses reappears in the 23–26 age group, although there are also responses at the lower level of the scale (3.0 and 1.0), which hurt the group's mean. Something similar happens with the population over 27 years of age. Although there is a considerable concentration of responses at the top of the scale (5.0), this does not overcome the negative responses (3.0–2.0). Thus, it is possible to point out that the mean of the group of women would be better if the standard deviation were not so large, as seen in the group of 23–26-year-olds, where the standard deviation attains a value of 1.01.

Thus, Fig. 1, although it corroborates the results of Table 3, shows that although the age groups of women show a downward trend of means, this may not be so strong. If the atypical responses were removed, the women's means in each age group would probably not show such low results. Even so, it should be noted that the results of the men in the last age group bounced considerably higher.

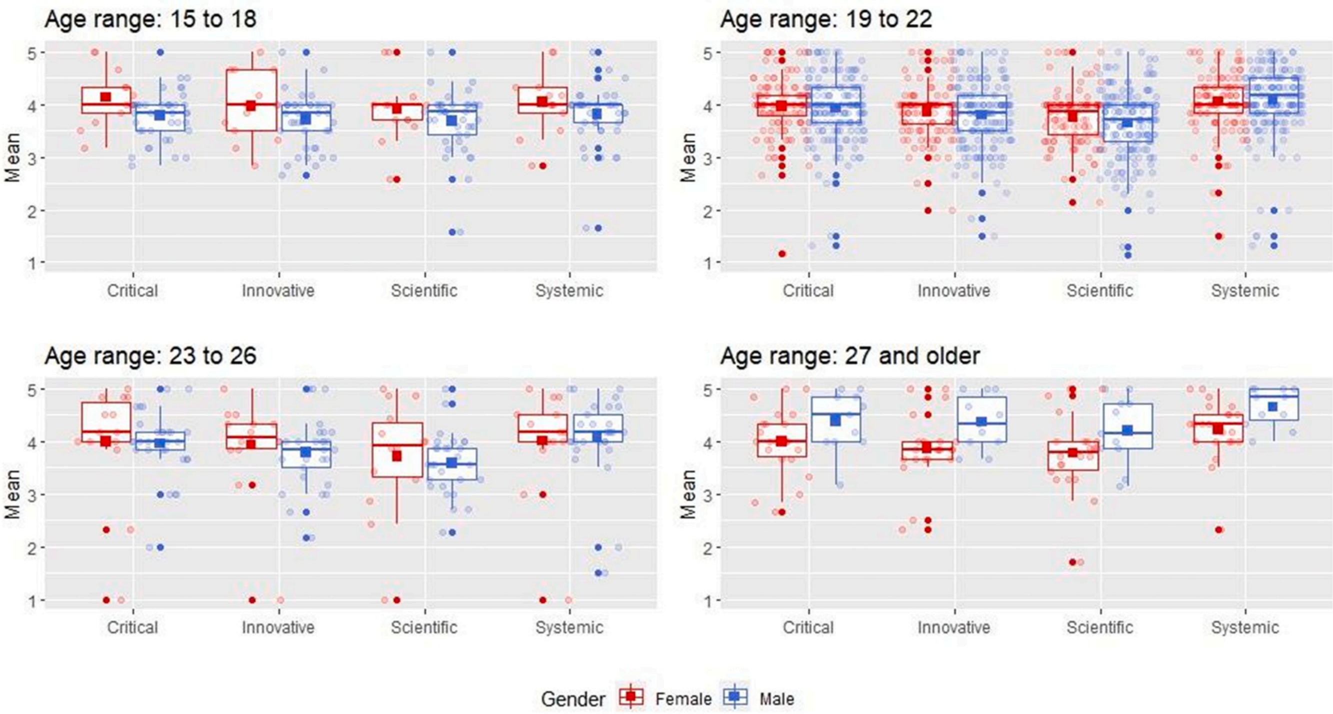

Fig. 2. Complex thinking sub-competencies. Boxplot analysis by age and gender. Source: Created by the authors.

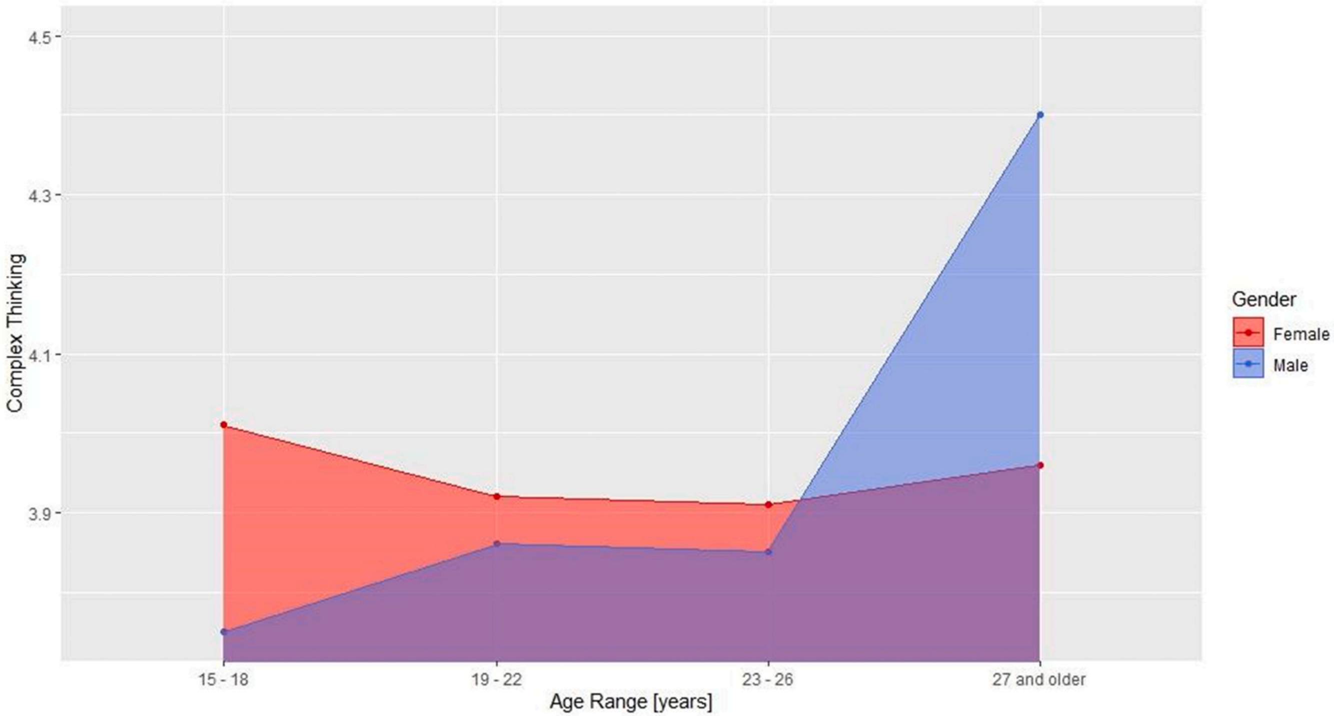

Fig. 3. Complex thinking competency: Line and area plot analysis by gender. Source: Created by the authors.

Table 5
Differential Item functioning test. Mantel-Haenszel method by gender.

Item	Stat	P-value	Effect size
1	2.08	0.14	B
2	1.10	0.29	B
3	0.10	0.74	A
4	1.04	0.30	B
5	0.01	0.91	A
6	0.01	0.91	A
7	3.27	0.07	B
8	2.17	0.14	B
9	0.55	0.45	A
10	0.89	0.34	A
11	0.17	0.67	A
12	0.36	0.54	A
13	9.74	0.00 * *	C
14	0.04	0.83	A
15	0.67	0.41	A
16	0.90	0.34	A
17	0.72	0.39	A
18	0.15	0.69	A
19	0.04	0.83	A
20	0.39	0.53	A
21	0.00	0.93	A
22	2.12	0.14	B
23	0.01	0.90	A
24	0.00	0.96	A
25	3.10	0.07	C

Effect Size; A = negligible effect, B = moderate effect, C = Large Effect
**p-value $\leq$ 0.05

To better understand the results beyond the overall competency, we delved into the results of each sub-competency of complex thinking. Table 4 displays the sub-competency results for the men's and women's age ranges. Fig. 2 accompanies this table with four boxplots, one for each age group.

The sub-competency of scientific thinking shows a similar trend for men and women. First, there are high results in the 15–18 age group (M.3.69-W.3.90). These means drop in the 19–22 range (M.3.65-W.3.77) and 23–26 age groups (M.3.59-W.3.71). They rebound in the over-27 age group (M.4.21-W3.78). As the boxplot shows, these trends could be influenced by the number of responses at the extremes of the scale. In the groups from 19–22 and 23–26 years of age, the responses concentrate in the lower part, but in the upper part among the groups from 15 to 18 and over 27 years of age. Thus, we see the intermediate groups are more critical in valuing their methodological knowledge, which was better at the beginning of their educational process, and improves again at the end of their professional training. As for the contrast between men and women, although women performed better than men in the first three age groups, men matched them and surpassed them resoundingly at the end of their formative process, having the best result of all sub-competencies in scientific thinking (4.21).

Interesting trends are also found in the second sub-competency. Men perceive development with age since as they grow older, their level of critical thinking also develops. However, women arrive with a good level of critical thinking at the beginning of their careers, but it drops and remains fixed throughout the rest of their training. Again, although men start off worse than women, in the end, they outperform women considerably (M.4.38-W.3.99). The boxplots show that the dispersion of responses is decisive for these results; in the first graph, there is no concentration of negative responses, but these are very present in the groups from 19 to 22 and from 23–26 years of age. As for the over-27 years age group, the women's graph shows many responses around 2.5–3.0, in contrast to the men, whose answers are mainly close to the overall mean for that age group.

As for the third sub-competency, innovative thinking, the results are similar to the overall competency. The men, although they start low (3.70), manage to rise to a very high average (4.26) at the end of their training process, while the women, although they start well (3.96), show very little progress, ending with a lower average (3.86). The reason, as seen in previous sub-competencies, is the presence of negative responses that influence the mean. It is possible to note that the women's boxes show more negative tendencies than the men's, so although the mean is not so different, the trend is negative.

Finally, the sub-competency of systems thinking displays a favorable trend for both genders since both men and women present means that tend to improve with age. However, again it is found that although the development of women is positive, it is not as considerable as that of men. Therefore, although at the beginning, women presented the best result (M.3.80-W.4.04), they were considerably surpassed by their male peers (M.4.65-W.4.22) in the oldest age group. This change is also noticeable in the boxplots since, in the 15–18 age group, the women's box has a clear upward trend compared to that of the men, which changes in the following age ranges until it is precisely the opposite in the group over 27 years of age.

Thus, it is possible to appreciate that the results by sub-competencies are very much in line with the behavior of the general perception of achievement, which can be summarized with the scatter graph presented in Fig. 3. This graph shows this differentiated process between men and women precisely: Although women start very well when they begin their university training, their

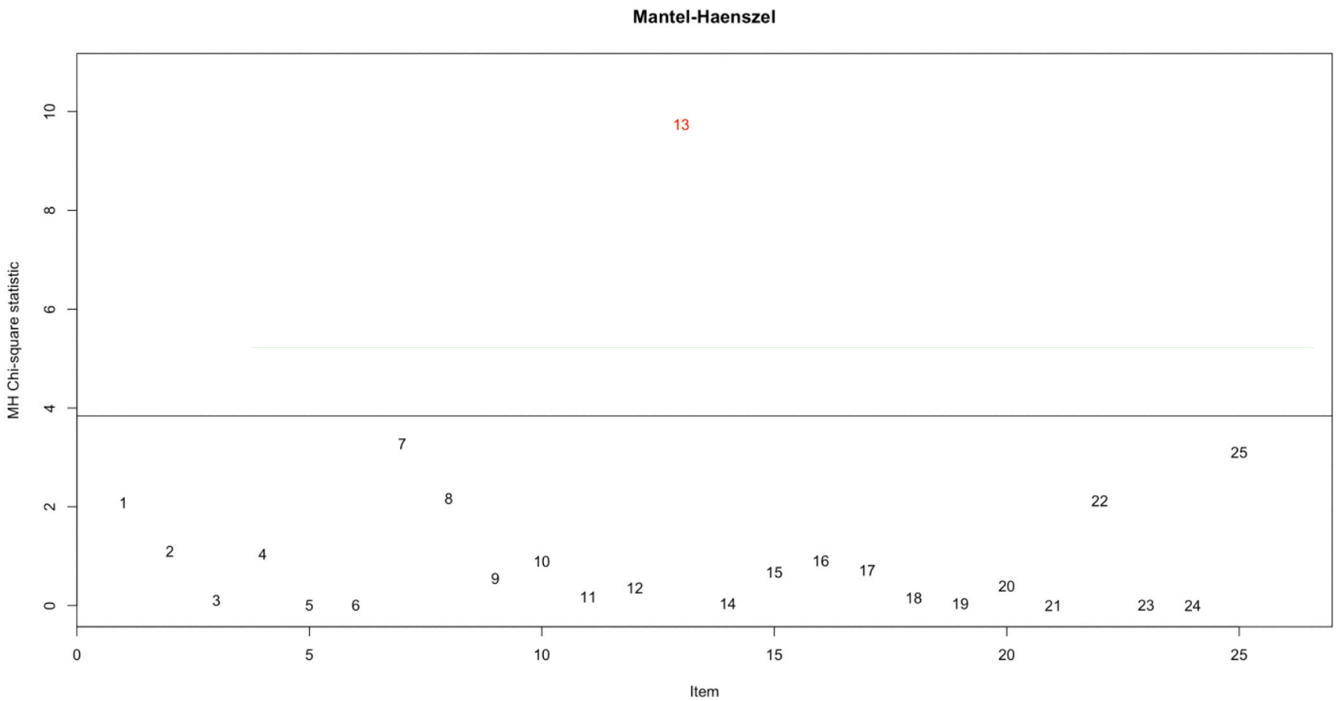

Fig. 4. Differential Item Functioning (DIF). Mantel-Haenszel method. Source: Created by the authors.

perception of achievement of complex thinking drops during their years, and although it recovers a little at the end, it does not manage to surpass its original state. This does not happen with men, who, although they start with a medium mean at the beginning of their career, climb in perceived competency as the years go by, attaining a high mean at the end of their formative process. Clearly, these results open many questions about what happens during and at the end of the training process of this population, where women see their perception of achievement diminished, while men clearly develop their self-concept along with their professional training. It would be relevant to analyze the population over 27 years of age, who are often students already working; perhaps the social environment influences the higher self-concept of men and the limited self-concept of women. This should be corroborated in a future study.

These results are in line with previous studies conducted in communities of female students and professionals, who reflect a more limited perception of their own capabilities as they grow older and gain work experience (Arredondo, Vázquez, & Velazquez, 2019; Arredondo, Vázquez, & Velazquez, 2019). In regions such as Latin America, the lack of opportunities, the lack of female role models and the lack of representation of women in industry affect the way young women perceive themselves, affecting the way they appreciate their own capabilities (Cruz-Sandoval, Vázquez-Parra, Carlos-Arroyo, & Del Angel-González, 2023; Cruz-Sandoval, Vázquez-Parra, Carlos-Arroyo, & Del Angel-González, 2023). Conversely, men, as they develop and receive the approval of the hegemonic patriarchal environment, strengthen the perception of their own capabilities, performing better than their female peers. Thus, although these results cannot be considered conclusive, they are in line with what has been previously analyzed and discussed in the Latin American region (Alonso-Galicia, Fernández-Pérez, Rodríguez-Ariza, & Fuentes-Fuentes, 2015; Alonso-Galicia, Fernández-Pérez, Rodríguez-Ariza, & Fuentes-Fuentes, 2015).

Considering the results of this study, we concluded that there is evidence of a gender gap in students' perceived development of complex thinking competency and its sub-competencies. The overall result and the specific results by indicators show that women's results underperformed their male peers despite, in most cases, initially being higher.

6. Conclusions

The purpose of this article was to present the results of a study conducted on a population of Mexican students to describe how age and gender can influence their perception of achievement of complex thinking competency and its sub-competencies. This competency was selected because it is a professionally valuable skill that provides an integrated vision of the environment and a high capacity for problem-solving. This study's results showed that, although women had a better perception of the level of competency and its sub-competencies at the beginning of their formative process, it diminished as they grew older, being surpassed by their male peers. Thus, the study confirmed a gender gap in the students' training process.

A relevant area of opportunity opened by this study concerns the widening of the gender gap by the group over 27 years of age, which, on many occasions, might have more social participation outside the university since they are the group usually already part of the labor market. This could influence the perceptions of both men and women because, although the results by gender remained balanced in the intermediate age groups, they separated considerably later. The results could be strongly influenced by hegemonic patriarchal environments, as in many workplaces in the Latin American region. Thus, the group over 27 years of age could reflect the reality of the Latin American environment more than the formative process.

Thus, it is possible to state that the present study presents some limitations that do not allow the results to be conclusive and exhaustive. First, it was not possible to have a balance of participants of all ages, which could influence the accuracy of certain categories more than others. In addition, the fact that some participants may already be in the labor market could affect their perception of the social reality of their environment, which could be a determining factor in establishing a self-concept of their abilities, skills and professional competencies. Finally, being a primarily descriptive study, it is not possible to clearly explain the reality that the data do not show, and it is possible to identify a gender gap, but without being able to explain the specific reasons for it. Even so, and despite these limitations, these results are considered valuable, as they shed light on a need and serve as a background for possible derivative studies and new lines of research.

In this sense, although this study corroborates the existence of a gender gap, it is necessary to delve deeper into the reason due to the practical impact of this study and its results. Both universities and companies must provide equitable environments for all students and workers, men and women, to strengthen their self-concept as their training process progresses and at the beginning of their work activity. It is not possible to say that professional training develops competencies if students do not perceive themselves so. Their lack of confidence may negatively impact seeking a job or facing a professional challenge. Equity in education must translate into not only having an equal number of men and women in the classroom but also that, regardless of gender, all students feel that they have equal opportunities to acquire and develop knowledge and competencies relevant to their profession.

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Conflicts of Interest

The authors declare no conflict of interest.

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Informed consent statement

Informed consent was obtained from all subjects involved in the study.

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