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Development of the Perception of Achievement of Complex Thinking: A Disciplinary Approach in a Latin American Student Population

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Abstract: This paper aims to identify whether there are statistically significant differences in the level of perceived achievement of complex thinking competence in a population of Latin American students from different disciplines. The intention is to corroborate or question the academic literature that categorizes certain types of thinking (systemic, scientific, and critical) as characteristic elements of some disciplines. Methodologically, the validated eComplexity instrument was applied to a sample of 370 undergraduate students from a Mexican university. The results showed that the highest means for systems thinking can be found in the disciplines of Engineering, Business, and Humanities, while the highest means for critical thinking can be found among architecture students. However, statistically, the results showed no significant differences upon an overall comparison of all disciplines. In conclusion, the findings of this study prove to be valuable for educational institutions seeking to develop complex thinking in their students, demonstrating that the disciplinary area is not a limiting factor in developing a perception of achievement in a particular competence and its sub-competences.

Keywords: higher education; educational innovation; undergraduate level; complex thinking competency; disciplinary statistical differences

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1. Introduction

The development of life competencies has become one of the primary objectives of contemporary universities [1]. Beyond ensuring that students acquire knowledge, educational institutions are committed to developing professional skills that enable their graduates to know how to accomplish certain tasks, especially problem solving. One of these competencies, complex thinking, values people's ability to reason when faced with challenging situations or problems. Globalization, daily use of technology, interactions in diverse environments, and the ever-increasing pressures of social movements mean that new professionals require a broader capacity for thinking than previous generations, which challenges universities to provide adequate training [2].

Instead of continuing traditional education, which focuses mainly on acquiring specific knowledge, today's educational institutions must develop competencies that would enable their students to think integratively about their reality along with a broad vision of the world. The competency of complex thinking comprises various thinking skills that provide the person with the tools to confront real problems as an individual or social agent with an integrated and holistic approach [3].

A relevant consideration is that traditional ways of thinking have been related to personal elements that individuals have perceived as their interests and strengths. Individuals have categorized professional choices by believing that certain types of thinking align with specific professional needs. For areas such as Engineering, Science, and Mathematics, individuals are expected to have a high level of scientific thinking. In contrast, high development in systems thinking is considered best for the disciplines of Social Sciences and Humanities [2]. However, these beliefs are not very accurate when considering problem-solving. They pigeonhole the types of thinking according to the profession chosen, considerably limiting the ability to develop integrated thinking in order to be able to tackle complex problems. It is essential to consider that before developing a competency, people must perceive themselves as capable of attaining a satisfactory level of mastery. However, disciplinary stereotypes could affect and limit their motivation [4].

Therefore, this article aims to approximate the perception of mastering the reasoning-for-complexity competency and its sub-competencies (scientific, systemic, and critical thinking) in a sample of students in a Latin American university. The intention was to identify statistically significant differences in a population of students during different semesters and from various disciplinary areas. To achieve this research goal, we applied a standardized instrument to measure the students' perception of their mastery level of reasoning for complexity and its sub-competencies. The intention was to gather sufficient data to help argue for the development of proposals and projects that would reduce possible gaps that exist in the different disciplinary areas that limit the competency development in some professional profiles.

1.1. The Competency of Reasoning for Complexity

The reasoning-for-complexity competency can be considered a mega-competency. Complex thinking or reasoning refers to a person's ability to apply integrative thinking to the analysis and synthesis of information in order to solve problems and develop continuous learning skills [2]. Complex thinking includes quantitative, qualitative, algorithmic, analogical, contextual, combinatorial, fuzzy, imaginative, provisional, heuristic, and ethical reasoning [1].

Complex thinking sees reality beyond a sum of parts or factors, i.e., as an integrated whole that considers the parts and the results of their interactions. According to Morin [3], complexity involves wholly understanding the environment, its dimensions, and the multiple elements that interact in any phenomenon. At the professional level, the competency of complex thinking enables individuals to face the challenges of reality comprehensively and strategically, considering various disciplines and approaches while being supported by their analyses and choices [4].

Complex thinking also encompasses high-level transversal competencies that must be considered in training programs. Critical thinking, problem solving, communication, collaboration, creativity, innovation, intercultural skills, productivity, responsibility, and leadership are complex thinking skills that are indispensable for decision making in professional fields [5]. Therefore, complex thinking is crucial for people's ability to solve their problems and for individuals to have the intellectual tools to face challenges.

Three types of thinking (or sub-competencies) are valued in mastering the reasoning-for-complexity competency:

- Systemic Thinking: This is the ability to integratively analyze inter- and transdisciplinary problems. Systemic thinking allows us to appreciate reality interconnectedly, considering its complexity and multiple elements. An individual who thinks systemically approaches problems holistically, avoiding reductionism and understanding the dynamics of the elements and the surrounding factors [6].
- Critical Thinking: Critical thinking is a sub-competency allowing individuals to evaluate the validity of reasoning in order to make logical judgements about a situation or problem, which is fundamental for understanding the contemporary world; it allows them to evaluate reality, problematize development, and rethink existing paradigms in terms of current affairs [7].
- Scientific Thinking: This sub-competency is based on the visualization and resolution of problems with objective, validated, and standardized methods that address reality

through inquiry and evidence-based research. The evidence adds certainty to decision-making processes for a complex world. Complementary to systems thinking and critical thinking, scientific thinking allows the individual to solve environmental challenges using various cognitive processes such as inductive and deductive reasoning and the formulation and testing of hypotheses [8].

1.2. Reasoning for Complexity and Disciplinary Areas

In educational research, it is not unusual to find studies that relate the choice of professional career to a particular student profile, which makes it possible to generate focal points of attention for educational programs upon entry, thus impacting the curricular offerings and professional activities. Studies such as those by Pennington, Vincent, Gosselin, and Thompson [9] have shown a clear correlation between the resolution of socio-environmental problems specific to certain professions and the profile and experience of the students, subsequently linking this with the learning style. In this same sense, Durán, Páez, and Nolasco [10] considered that globalization and new environmental needs require certain specific profiles among university students, so universities must design or adapt curricular programs relevant to these needs.

The literature contains studies that relate types of thinking to specific disciplines. For example, in terms of types of thinking, Lema-Ruiz, Espinoza-Cevallos, Tenezaca-Romero, and Ruiz-Sanginez [11] reported differences among different groups of professionals by assessing that reasoning is partially socialized and therefore common among groups. For Hiver, Al-Hoorie, and Larsen-Freeman [12], thinking styles are developed and modified according to the convenience and needs of individuals, with certain ways of thinking being encouraged according to the community, cultural contexts, and types of problems faced. In this regard, it is possible to find various studies that seek to identify the types of thinking most suited to specific disciplines, under the premise that there are differences among professions and as to how they reason and resolve problems.

Encouraging different types of thinking in university training programs supports high-level training. According to Eyzaguirre [13], students in disciplines related to philosophy tend to present notable development in critical thinking, which aligns with the studies conducted by Azurín [14] and Valadez and Zarabozo [15]. Analyzing a sample of humanities and social sciences students, they reported a tendency to develop a more critical vision of reality and the environment when problem solving and writing argumentative texts. Along the same lines, Gutiérrez and Medina [16] highlighted the importance of critical thinking in the disciplines associated with architecture and design, considering that these professionals must analyze, reflect, and question their reality in order to transform it. For Martínez and Jiménez [17], creative thinking is the most relevant during training for professions focused on artistic creation, design, and architecture.

Scientific thinking is associated with health training. For example, Paredes [18] and Rojas and Cortés [19] emphasized the importance of health professionals developing scientific thinking on a par with critical thinking. Medical students must be aware of reality's ethical and social implications and show openness to continuous feedback in a constantly changing world. Colina and Camacho [20] also noted that teaching in the medical sciences emphasizes scientific thinking, leaving aside the development of systemic and critical thinking.

The training of engineering professionals must also include scientific competencies. Ruidiaz Villalobos [21] conducted a study in which he verified the development of scientific thinking in STEM (Science, Technology, Engineering, and Mathematics) disciplines in contrast to other professional groups. Chamizo [22] and Vázquez and Manassero [23] complemented that finding by pointing out that science education in engineering should seek to develop argumentations of critical thinking, which would improve the scientific thinking characteristic of STEM professions.

One could continue to cite studies reinforcing the idea that different disciplinary areas predominantly involve certain types of thinking, considering this a strength and not a limitation when solving problems beyond their discipline. Previous studies that have been analyzed concluded that types of reasoning are characteristics of certain professions, hence solving a complex problem would benefit from multi-disciplinary collaboration.

Sudden changes, such as those resulting from COVID 19, have put the need for complexity skills training into perspective. The contemporary environment often demands professional capacities beyond the specific knowledge or skills of one discipline. There must be extended and comprehensive competencies that could provide the tools to face the complex reality in which professionals find themselves [24]. According to Drucker [25], factors such as digitalization have led to the modification of student profiles in disciplines such as humanities, where certain types of thinking traditionally dominated.

Thus, our research sought to identify whether the presence of significant differences among the types of thinking or reasoning in a multi-disciplinary sample population is arguable. We intended to determine the strengths or opportunity areas that educational institutions should consider in each discipline in order to integrate the development of the complex thinking competency. As pointed out in the theoretical framework, complex thinking is a necessary and highly relevant competency in the contemporary world, and so the professional's disciplinary area should not limit it. The originality of this work is its focus on developing complex thinking as an integral competency, thus departing from the limitations of the students' disciplinary areas.

2. Materials and Methods

In the present research, we administered the eComplexity instrument to a sample of 370 university students. Afterwards, we conducted a statistical analysis to obtain the mean, variance, scale impact, and relative dispersion, and we performed significance tests. The purpose was to identify whether there were indeed significant differences among the different subject areas in the students' perceptions of their mastery level for the complexity-for-reasoning competency. The instrument used is shown in Table 1.

Table 1. eComplexity instrument.

	Category	No	Item
Reasoning for complexity	Systemic thinking		Knowledge
		1	I can identify the criteria needed to determine a research problem.
		2	I can identify variables from various disciplines in a research problem.
		3	I can find associations between variables, conditions, and constraints in a research project.
		4	I can identify databases within my discipline and other areas that could contribute to my research.
			Skills
		5	I participate in projects that present challenges/problems to be solved with multidisciplinary perspectives.
		6	I can organize information to solve research problems efficiently and effectively.
		7	I can solve research problems by interpreting data from different disciplines.
			Attitudes or values
		8	I value learning something new in the field of research.
		9	I apply strategies that facilitate the comprehension of complex texts.

Table 1. *Cont.*

Category	No	Item
Scientific thinking		Knowledge
	10	I can identify the elements needed to formulate a research question.
	11	I can distinguish the structure required for writing research reports used in my area or discipline.
	12	I can identify the structure of a research paper used in my area or discipline.
		Skills
	13	I apply the necessary research method to solve the problem posed.
	14	I design research instruments coherent with the research method used.
	15	I analyze problems from the general to the particular and vice versa.
	16	I generate and evaluate research hypotheses.
		Attitudes or values
	17	I qualify for truthfulness through data analysis.
Critical thinking		Knowledge
	18	I can discern the process required to critically analyze different types of texts.
	19	I can identify false arguments in a text or discourse.
		Skills
	20	I constantly self-evaluate the goals achieved.
	21	I formulate my judgments on a problem with reasoning based on scientific knowledge.
	22	I apply innovative solutions to research problems.
		Attitudes or values
	23	I review my papers to comply with ethical guidelines before submitting them for review.
	24	I critically evaluate the solutions derived from a research problem.
	25	I appreciate criticism of my writing to improve it as often as necessary.

Table 1 shows the three dimensions that make up the instrument: systems thinking, scientific thinking, and critical thinking. It also shows how each dimension is subdivided into three categories: knowledge, skills, and attitudes or values. Finally, the items corresponding to each dimension can be seen.

2.1. Participants

The eComplexity questionnaire was administered to a sample of 370 first-to-ninth semester undergraduate students from a private university in Western Mexico. The undergraduate student population of this institution was approximately six thousand students, so the sample of 370 students was statistically representative. The students were from 17 to 27 years old. The convenience sampling included students with diverse disciplinary careers. The aim was to achieve the best possible balance between men and women in the sample, resulting in 189 women and 181 men. This proportion is approximately the same as that of the general population of the institution, which is 48% male and 52% female. The areas of knowledge participating in the research were Engineering, Business, Medicine, Social Sciences, Humanities, and Architecture. The application of the instrument and the corresponding data collection took place between August and November 2021.

The sample sizes for the subject areas participating in the study can be seen in Figure 1.

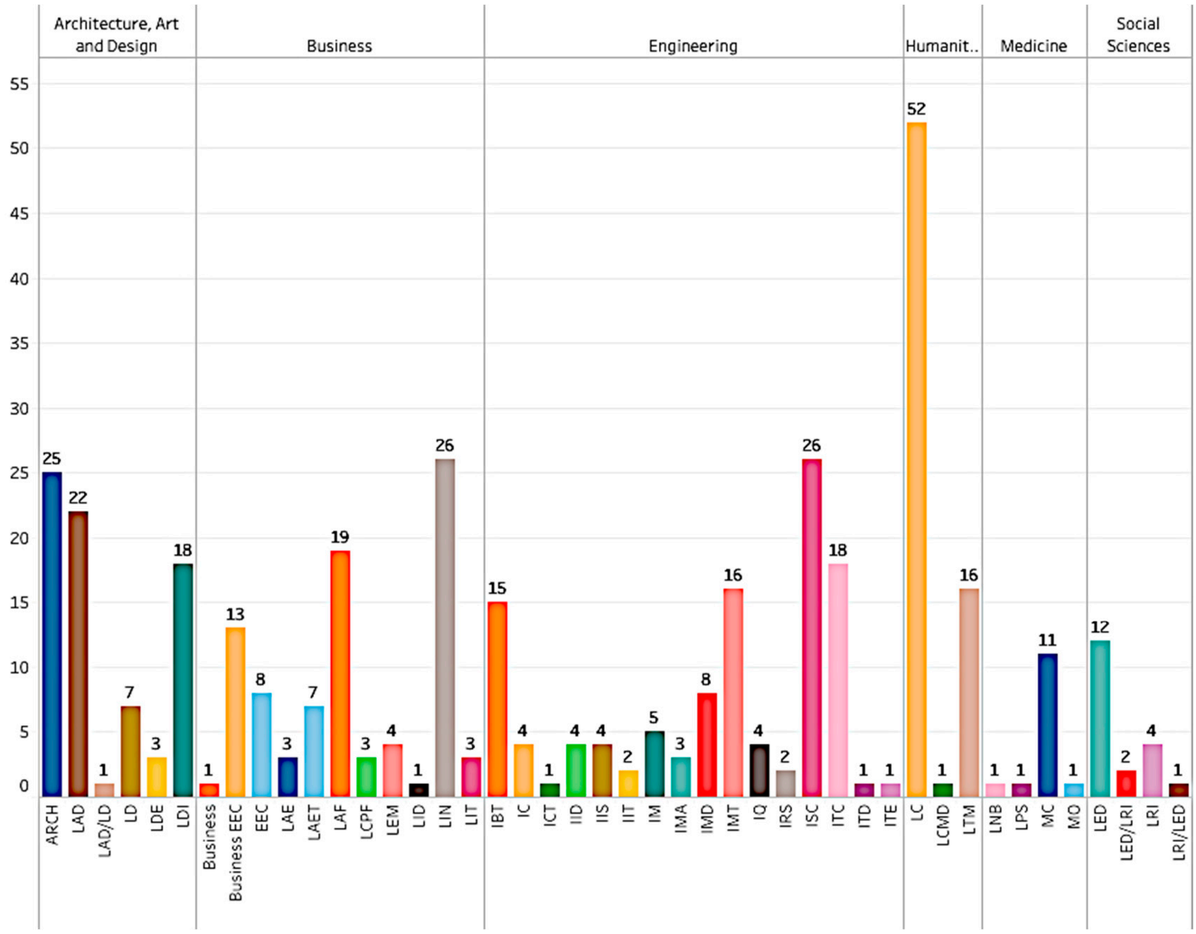

Figure 1. Participants in the study by area of knowledge.

As shown in Figure 1, Engineering had the largest sample with 114 students, followed by Business with 88, Architecture with 76, and Humanities with 69. The low-number samples were Social Sciences and Medicine with 19 and 14, respectively. Figure 1 also shows the degree program representation within the areas of knowledge involved in the research. It is noteworthy that the differences in the number of participants per area of knowledge also largely corresponds to the number of degree programs in those areas, with Engineering and Business being the disciplines with the highest number of degree programs offered.

2.2. Instrument

The eComplexity instrument was aimed at measuring the participants' perception of their mastery of the complexity-for-reasoning competency and its sub-competencies. It is an instrument that has been validated theoretically and statistically by a team of experts in the field [26]. The thirteen specialists who served as judges had an average of 20 years of experience. They evaluated the instrument considering the criteria of clarity, coherence, and relevance and also provided comments on the wording of the items.

The validation procedure of the eComplexity instrument consisted of the first phase of theoretical validation. The theoretical validation was based on the analysis of instruments measuring the competency of the reasoning for complexity and the three sub-competencies: scientific, critical, and systemic thinking.

Twenty-five items comprised the structure of the instrument, divided into the three sub-competencies of systemic thinking, scientific thinking, and critical thinking. In turn, each sub-competency was divided into knowledge areas, skills, and attitudes or values [4].

For the validity based on the internal structure, we used factor analysis. Factor analysis is a tool used in the design or validation of psychometric tests (Kaplan and Saccuszzo, 2017). There are two factor analysis processes: exploratory factor analysis (EFA) (Lloret-Segura et al., 2014), which helps to determine the number of factors or dimensions that explain the test, and confirmatory factor analysis (CFA) (Keith, 2019), which helps to check the instrument's fit. Both procedures were used in the present research.

Regarding the exploratory factor analysis (EFA), we obtained a Kaiser–Meyer–Olkin index (KMO) > 0.80 and a significance of $p < 0.05$. These data were very indicative of the internal structure since indices greater than 0.80 are satisfactory (Kaiser, 1979; Lloret-Segura et al., 2014) for a good EFA, where the factor loadings exceed 52% variance across three factors (with a correlation greater than 0.40).

Subsequently, we proceeded to perform the CFA. With the CFA, it was possible to detect that some indices could be adjusted to increase the validity of the internal structure of the test (Bentler and Yuan, 1999); therefore, we revised the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the goodness-of-fit index (GFI), which were sought to be greater than 0.80. We also obtained the root mean squared error of approximation (RMSEA) and the standardized root mean squared residual (SRMR), which were very close to the 5% confidence value that corroborates the validity of the indexes. The analysis allowed us to identify the items that contributed the least to the AFC: items 8, 22, 23, and 25. However, it was not crucial to eliminate them; even if the 25 items had been kept, the validity of the instrument would have remained high. For further information on the psychometric properties of the instrument mentioned in the previous paragraphs, the study carried out on this aspect can be reviewed (Castillo-Martínez et al., under evaluation).

Data Analysis

The data analysis used descriptive statistical measurements such as the mean and standard deviation, complemented with significance tests conducted among students from different disciplines to determine statistically significant differences in their perception of their mastery of reasoning for complexity.

The primary purpose of the hypothesis tests was not to determine the actual size of the difference between two measurements but to demonstrate that the difference exists (i.e., it is non-zero) given the observed data. More specifically, hypothesis testing requires two hypotheses: the null hypothesis (often written as H0) and the alternative hypothesis (often written as Ha or H1) [27].

Two types of alternative hypotheses were used for the present study: one-sided and two-sided. A one-sided alternative hypothesis can be either right-tailed (indicating that the actual value of the population parameter considered is greater than the hypothesized value in H0) or left-tailed (indicating that the actual value is less than the hypothesized value) [27].

For more information about the instrument or its validation process, we recommend reviewing the paper by Castillo-Martínez, I. M. and Ramírez-Montoya, M. S. (2022)—eComplexity instrument: Measuring higher education students' perception of their reasoning for complexity competency, and the paper by Castillo-Martínez, I. M., Ramírez-Montoya, M. S., and Torres-Delgado, G. (2021, under evaluation)—Reasoning for complexity competency instrument (e-Complexity): content validation and expert judgment.

2.3. Ethical Aspects

This study was conducted in accordance with the Declaration of Helsinki and was reviewed by WritingLab at the Institute for the Future of Education of the Tecnologico de Monterrey, which had approved its development, implementation, and publication. All participating subjects provided a statement of informed consent.

3. Results

The statistical analysis of this research allowed us to identify results according to knowledge areas and items. We observed useful results in the knowledge areas, as shown in Table 2.

Table 2. Results according to knowledge area.

	Medicine	Architecture	Humanities	Social Sciences	Engineering	Business
$\overline{x}$	4.13	3.86	3.97	4.11	3.90	3.84
s =	0.83	0.93	0.89	0.75	0.84	0.87
Imp Esc =	82.7%	77.2%	79.3%	82.1%	78.0%	76.8%
drel =	20.1%	24.1%	22.3%	18.3%	21.5%	22.6%

Source: Own creation.

Table 2 shows the mean ($\overline{x}$), standard deviation (s), scale impact (Imp Esc), and relative dispersion (drel). It can be observed that the sample mean was higher for the areas of Medicine and Social Sciences, which is reinforced by their scale impacts of 82.7% and 82.1%, respectively. The lowest sample mean was in the area of Business (3.84). Generally, students in the different subject areas gave themselves high scores in their perception of their mastery of reasoning for complexity.

Table 3 shows the impact on the scale of the different areas of knowledge, both globally and by item. Item 8 (I value learning something new in the field of research.) had the highest scale impact in three of the knowledge areas: Engineering, Business, and Medicine. Item 25 (I appreciate criticism of my writing in order to improve it as often as necessary.) scored the highest in the remaining three areas: Architecture, Social Sciences, and Humanities. As for the lowest score, this was observed in three subject areas with item 14 (I design research instruments consistent with the research method used.): Engineering, Business, Humanities; in Social Sciences and Medicine, the lowest score was for item 22 (I apply innovative solutions to research problems). Finally, in Architecture, item 11 (I can distinguish the structure required for research report writing used in my area or discipline) had the lowest score. On the other hand, the type of thinking that predominates in each area of knowledge is shown in Table 4. We excluded the areas of Medicine and Social Sciences because the samples were less than thirty.

Table 3. Impact on scale according to areas of knowledge.

Impact on Scale					
Medicine	Architecture	Humanities	Social Sciences	Engineering	Business
87.1%	77.4%	78.0%	83.2%	79.1%	76.6%
84.3%	74.5%	74.5%	78.9%	79.6%	75.0%
82.9%	73.9%	76.2%	76.8%	78.1%	76.4%
84.3%	76.8%	80.6%	85.3%	78.9%	78.0%
74.3%	74.2%	80.9%	86.3%	75.3%	75.9%
80.0%	83.9%	86.1%	83.2%	81.9%	84.1%
81.4%	75.0%	81.7%	78.9%	77.9%	75.0%
92.9%	90.0%	89.9%	85.3%	90.0%	87.5%
80.0%	79.2%	79.4%	77.9%	72.3%	75.9%
81.4%	74.7%	77.4%	82.1%	74.0%	75.7%
80.0%	69.2%	73.9%	77.9%	74.9%	72.5%
85.7%	68.9%	73.6%	82.1%	74.7%	71.4%
85.7%	76.8%	74.5%	76.8%	75.1%	73.6%
75.7%	71.1%	71.6%	78.9%	69.6%	70.2%
88.6%	77.9%	81.4%	82.1%	81.2%	81.4%
84.3%	75.8%	79.4%	80.0%	77.7%	74.5%

Table 3. *Cont.*

Impact on Scale					
Medicine	**Architecture**	**Humanities**	**Social Sciences**	**Engineering**	**Business**
87.1%	79.2%	80.3%	84.2%	79.6%	79.1%
78.6%	71.6%	74.2%	80.0%	75.6%	72.5%
75.7%	70.5%	74.2%	84.2%	75.3%	73.4%
80.0%	78.4%	82.9%	81.1%	78.9%	79.5%
85.7%	76.1%	75.9%	87.4%	80.9%	75.7%
72.9%	77.4%	80.0%	75.8%	75.3%	75.5%
84.3%	83.4%	84.3%	86.3%	77.2%	78.0%
85.7%	81.8%	81.2%	87.4%	78.8%	76.4%
88.6%	93.2%	90.7%	90.5%	86.7%	87.5%
82.7%	77.2%	79.3%	82.1%	78.0%	76.8%

Table 4. Averages according to type of thinking in each area of knowledge.

	Types of Thinking		
	Systemic	**Scientific**	**Critical**
	$\overline{x}$	$\overline{x}$	$\overline{x}$
Engineering	3.96	3.79	3.93
Business	3.91	3.74	3.87
Architecture	3.92	3.71	3.95
Humanities	4.04	3.83	4.02

Source: Own creation.

Table 4 shows that systems thinking had higher mean values in Engineering, Business, and Humanities. In Architecture, the highest mean occurred in critical thinking. In Business, there were larger differences between the means of the different types of thinking. In the other disciplines, the differences between the means of the three types of thinking were minor. Table 5 complements this analysis to show the sampling mean differences between subject areas among types of thinking.

Table 5. Sampling mean differences between subject areas among types of thinking.

	Systemic Thinking			
	Architecture	Humanities	Engineering	Business
Architecture	0			
Humanities	−0.12	0		
Engineering	−0.05	0.03	0	
Business	0.004	0.09	0.05	0
	Scientific Thinking			
	Architecture	Humanities	Engineering	Business
Architecture	0			
Humanities	−0.12	0		
Engineering	−0.08	0.03	0	
Business	−0.03	0.09	0.05	0
	Critical Thinking			
	Architecture	Humanities	Engineering	Business
Architecture	0			
Humanities	−0.07	0		
Engineering	0.02	0.09	0	
Business	0.09	0.16	0.06	0

Note: Significant at <0.05. Source: Own creation.

Table 5 shows a more significant sample difference between the areas of Humanities and Architecture for systems thinking and scientific thinking. In critical thinking, the sample difference is larger between the Humanities and Business areas. Hypothesis tests were conducted to determine whether these differences were statistically significant. The results were: systems thinking ($t = -0.86$, $p < 0.05$), scientific thinking ($t = -0.73$, $p < 0.05$), and critical thinking ($t = 1.127$, $p < 0.05$). Hence, there is no basis for thinking that the differences between the mean values of Architecture and Humanities in systems thinking and scientific thinking are statistically significant; the same is true for the critical thinking means in Humanities and Business.

4. Discussion of Results

The mega-competency of reasoning for complexity contains the sub-competencies of scientific, systemic, and critical thinking. In this study, as Table 3 shows, scientific thinking obtained the lowest mean (3.79), critical thinking attained a considerable mean (3.93), and the most significant mean was achieved for systems thinking (3.96). These results are in line with those of Chamizo [22] and Vázquez and Manassero [23] but differ from those of Ruidiaz Villalobos [21], who found the preponderance of scientific thinking. Therefore, we can identify that systemic thinking was predominant, and not scientific thinking, as reported in the sources consulted.

The competency of reasoning for complexity can be studied from the formation of various disciplines to locate differences in scientific, critical, and systemic thinking. Table 4 shows that the sample differences between Humanities and Architecture and between Humanities and Business, based on a hypothesis test (*t*-test), were not statistically significant. Humanities students had the highest sample mean in systems thinking (4.04), followed by critical thinking (4.02). Among architecture students, critical thinking had the highest mean (3.95). These results are consistent with those of Lisha [28], where the highest mean corresponded to systems thinking, followed by critical thinking, as noted by Eyzaguirre [13]. Gutiérrez and Medina [16] stated the relevance of critical thinking in transforming spaces. If the study were carried out in isolation in the disciplinary areas, it would surely yield differentiated results; however, when an analysis is performed as a whole, it is possible to observe that the variations in the type of thinking by discipline do not have a verifiable argument.

The measurement of the reasoning-for-complexity competency needs to be performed with various instruments that complement students' perceptions. As can be seen from the results, although there are differences in the means of the different types of thinking by discipline, these were not statistically significant when analyzing the sample differences and with the hypothesis test (*t*-test). The largest differences in the type of thinking were between the mean for systems thinking in the humanities (4.04), which had the highest mean, and the mean for scientific thinking in architecture (3.71), which had the lowest mean. As Morin [3] pointed out and as Silva and Iturra [24] confirmed, the competency of complex thinking and its sub-competencies are equally valuable for contemporary professionals, regardless of their disciplines. Current problems have been shown to be best tackled with a broad, critical, systematic, and methodological approach. Thus, we should not become entrenched in the idea that because we are professionals in the humanities, engineering, or medicine, how we reflect and reason are inherent in the knowledge and competencies that pertain to the profession.

5. Conclusions

The present study seeks to provide a precedent that academically questions the differentiated analyses of the types of thinking according to discipline, thus responding to the research questions about the possible correlations between types of reasoning and the disciplines. The results analyses and discussion indicated no statistically significant evidence that certain types of reasoning are specific to some professions. It is acknowledged that most of the experimental results are in line with the research results found in the academic literature, which shows that this experiment is relatively reasonable and effective. The fact that no statistically significant differences in the level of perceived achievement were found between subjects from different disciplines shows that although the existing literature is correct, the subject has not been approached in an integrated way, one which considers the achievement between disciplines in isolation rather than in contrast between all disciplines. Thus, the present study defends the need for all professionals to develop the competence of complex thinking in an integral way; that is, considering their sub-competences in the same way regardless of the discipline they belong to. This is argued by the fact that in the contemporary world, every professional must address complex problems holistically, with multidisciplinary knowledge and without being limited by a single type of disciplinary thinking.

In a practical sense, the data are of value to academic, scientific, and humanities communities interested in undergoing training in order to develop high-level competencies. Implications include the need to integrate training strategies that allow for the scaling up of the competency for complexity, which encourages problem solving, high-level thinking, and creativity in proposing solutions. Implications for research include the development of complementary instruments that measure complex thinking beyond perception in order to assess the competency of actions and to continue studying the differences in disciplinary areas resulting from training strategies. We recognize that the present study may be limited because it was only carried out in one institution. However, the intention was to shed light on the need for further studies with a similar perspective. In addition, a study limitation was the low number of participants in the health science (medicine) and social science samples. Their inclusion could have made the discussion more enriching in comparing the results with the studies in the academic literature presented in the theoretical framework. On the other hand, it is recognized that there is a limitation in not considering the possible existence of cultural differences between student profiles in Western and Latin American countries and the relationship between field of study and reasoning skills for complexity. Cultural differences between students from different countries may be reflected in perceptions of reasoning competences for complexity, therefore comparative studies are recommended to broaden the area of study and to shed light on implications for practice in university education. These limitations open the possibility for future studies to include institutions from other regions and to integrate the disciplinary areas that the present analysis could not include. Despite these limitations, it is hoped that the present study demonstrates the need for educational institutions and governments to promote, in educational practice, a comprehensive vision of professional competencies, one that goes beyond student profiles and disciplines. This paper is an invitation to continue developing high-level competencies in university education.

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