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# Critical Thinking and Teaching Mathematics: An Analysis from Education

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***Abstract***

*This paper analyzes the critical thinking and teaching of mathematics from the perspective of education. Its purpose is to determine the link between the variables and their consequent analysis. Methodologically, it takes a mixed approach. It uses a correlational design and systematic review in the Scielo and Scopus databases over the past five years. The sample consisted of 103 professors and 36 articles. The technique was the survey. Inferential statistics were used using the SPSS statistical package. The results indicate that Spearman's Rho is 0.579, showing a moderate positive correlation. In conclusion, there is a moderate correlation between teachers' critical thinking and their way of teaching mathematics, showing that 48.5% of them reach a high level in their teaching method. At the same time, the systematic review shows that the studies are focused on two components; Social Development and Educational Praxis.*

***Keywords:*** *Teaching, Primary Education, Mathematics, Critical Thinking*

## INTRODUCTION

The link between critical thinking (CP) and mathematics teaching (MS) in education is under discussion, as are the ways in which teachers encourage CP when teaching mathematics lessons. Since the last century, this category has been understood within the realm of argumentation and reasoning, with the purpose of justifying judgments, behaviors, and skills in certain disciplines (Suárez et al., 2018). It is important at all levels of education, due to the criticality it develops in the activities (Rodríguez et al., 2023). This reflexive reasoning with respect to what is heard and read, its feature is the credibility with which the skeptic is assumed (Herrero, 2016).

Facione (2007) It relates to cognitive skills and dispositions that facilitate interpretation, analysis, evaluation, inference, explanation, and self-regulation, and is viewed positively, Suárez et al. (2018) It states that it is associated with attitudes, emotions and values. It is an ability to detect reasoned arguments and assumptions (Lopez, 2012). Saiz (2018) To possess critical thinking is to think intellectually, Ossa-Cornejo et al. (2017) They describe it as a skill of high cognitive demand and represent a challenge that involves a gradual process. Education plays a crucial role, requiring the implementation of various strategies (Ojose, 2022).

The teacher as mediator generates PC referents when teaching mathematics (Pachón, 2013). Trainees are able to solve problems of any kind (Pando, 2016). The PC allows development in the field; Personal, academic and social (Remache-Bunci, 2019). For Chrobak (2017) It is linked to the mastery of the metacognitive processes of learning. This involves the activation of previous experiences, in order to achieve a desired situation (Moreno-Pinado & Velázquez, 2017). By using this skill pertinently and consciously.

Assessing critical thinking is a difficult task. Street (2013), it is possible to do this through various strategies, such as standardized tests, observations, questionnaires, among others. This requires the implementation of reasoned plans for decision-making and problem-solving (Saiz & Fernández, 2012). It involves complex skills, developing critical thinkers who succeed in the activities they perform (Lin et al., 2023). That mediates solutions in the flourishing of objective reality (Jaimez, 2016). In this scenario, it is essential to clarify the link between

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the study variables and to review the articles from the systematic review, making an analysis from the perspective of education.

## THEORETICAL REFERENCES

The dimensions of the PC that are analyzed are; logic, substantive, contextual, dialogic and pragmatic. The Logical Dimension It describes the ability to self-evaluate with clarity, reasoning, and conceptual coherence. It facilitates the ability to reflect clearly, showing a connection between thought and language. It deals with the validity of the argument, the meanings, thus determining the veracity or denying it (Gamut, 2002). It contributes to the generation and understanding of knowledge (Torres-Miranda, 2020).

The Substantive dimension It examines objective information derived from science. It allows us to appreciate the thought communicated through grounded information, well-developed concepts, and systematic methods related to a specific field of knowledge (Remache-Bunci, 2019). Choose questions that clarify reality in order to understand its characteristics within an appropriate time and space frame (Vargas-Sandoval, 2021).

The Contextual dimension It refers to understanding and analyzing the environment that influences a specific thought. It involves the ability to understand and value the circumstances surrounding a specific event, situation, or idea. This includes knowing the social, historical, cultural, political, and economic context in which an idea arises or a decision is made. Berger et al., (2014) Students bring with them context-specific learning experiences, which constitute the product itself and are essential because they integrate contextual and individual aspects relevant to learning. These elements are associated with the existing educational means of learning (Estévez et al., 2021).

The Dialogic dimension It is based on listening carefully to the ideas of others and sharing lived experiences through dialogue. This makes it possible to analyze thoughts in comparison with what is expressed, in order to distinguish and understand other points of view (Remache-Bunci, 2019). Argumentation is an effective strategy for persuading the interlocutor through the use of dialogue.

The Pragmatic dimension It evaluates thought in terms of its purposes, carries out practical actions, reflects ethics and prudence. For Ojose (2022)herself Try to use techniques that encourage learning, solve problems by activating skills, and maintain coherence between what has been learned and its application. From the anthropological perspective, it is related to the field of meaning processes, which need validation and the establishment of methodologies for the use of knowledge (Basso, 2021).

Regarding MS, it focuses on the educational procedure that provides tools to solve different situations of daily life. Olfos et al., (2022) They indicate three elements that must be present in the early childhood teacher: mastery of the contents, understanding of mathematical thinking in young children, and ability to teach. Monroy (2014), a mathematical environment needs the acceptance of the learning group, the use of logic, mathematical evidence, the promotion of reasoning and the resolution of problems applicable to everyday life. Mathematics should not be reduced to memorizing formulas or rules. Mathematical competence depends on other technological skills and abilities, which allow the development of reasoning, argumentation, modeling, and problem-solving using symbolic language (Vaillant et al., 2020).

Learning math involves activities such as measuring, counting, playing, estimating, explaining, and demonstrating. It also requires the teacher to be constantly updated to address issues related to the actual context (Zulay, 2020). ICT resources in MS contribute effectively and respond to new trends in the use of technologies that allow the development of mathematical skills (García-Gonzáles & Solano-Suarez, 2020). Using these tools effectively to promote learning is vitally important as a mediator (Muñoz, 2022).

Vanegas and Camelo (2018), the teaching of mathematics should offer experiences that are socially relevant to both students and the teacher. This process involves the participation of its agents and also considers the day-to-day reality. Context is crucial in the process, because it gives meaning in teaching and learning (Pachón, 2013). In addition, it is crucial to incorporate gamification into the teaching of mathematics, using play to keep the student motivated while learning (Vega-Díaz et al., 2022).

MS requires taking a more hands-on approach, where ideas are put into practice to be experienced. People with a pragmatic attitude often act quickly and confidently on ideas and projects they find attractive (Gallego & Nevot, 2008). Teaching content requires considering the different types of learning, the social and family context, as well as all the complex conditions that can hinder the development of competencies. The teacher must use innovative strategies when teaching mathematics (Zulay, 2020).

MS is involved with the following dimensions; Familiarization with the problem, this skill requires the learner to become familiar with the situation and the mathematical problem using simple language (Polya, 1989). May (2015), It is essential to ask questions that allow students to contextualize the problem. This involves understanding mathematical meanings and communicating them both orally and in writing, using appropriate language to translate between different representations (MINEDU, 2015). This approach is related to the sequence of mathematization, which consists of representing the reality of the problem (MINEDU, 2013).

The dimension of Finding and executing strategies It involves investigating, proposing, selecting important strategies to solve a certain problem. This should start coherently by finding the operations that were previously analyzed as viable to find. (Polya, 1989). For May (2015) These procedures must produce results, and their implementation depends on the particularities of the problem at hand. This requires the use of prior knowledge and a mathematical strategy to approach the problematic situation, which involves interpreting the resulting solution (MINEDU, 2013).

The Dimension socialize their representationsrequires trainees to share with their peers the experiences, results, strategies employed and difficulties encountered. The vocabulary, the ideas, the procedures that lead from the concrete to the abstract are important. Facilitates the assimilation of definitions through the use of educational materials, whether tangible or abstract (MINEDU, 2013). These representations are experiential, symbolic, graphic and pictorial (MINEDU, 2015). These lead to extending the response to the problem (May, 2015).

The Dimension Reflection and formalization, consists of the student making links between mathematical concepts and procedures. This makes it possible to create a structured sequence of techniques, technologies and materials using them in an effective and adaptable way (MINEDU, 2015). The learner has the opportunity to return to the result of the approach, review it, confirm their answer, question themselves and answer them in order to continue improving (Polya, 1989).

Regarding the dimension Raising other problems, the trainee uses all his experience to formulate problem situations. To raise the question they are proficient in the language of mathematics, information about knowledge, methods for creating problems, skills in handling symbolic mathematical expressions, sequencing, and formulating hypotheses (MINEDU, 2013). The problems formulated must be placed in various circumstances and meet the intended mathematical objective (Blanco et al., 2015). Sometimes, students solve mathematical calculations without fully reading the problem, focusing only on the numerical data and without considering the qualitative aspect of it. (Monroy, 2014).

## METHODOLOGY

The study is part of the mixed approach. On the one hand, it assumes a non-experimental research of correlational design, being its study sample 101 teachers from the UGEL El Collao-Ilave – Peru, the instrument used was a Likert-type questionnaire with 24 and 25 items for CP and MS respectively, it was validated by expert judgment and the reliability of Cronbach's Alpha. On the other hand, in the qualitative aspect, it assumes the systematic review of 36 articles regarding the categories of analysis in the last five years in the Scielo and Scopus databases. The search was conducted in October and November 2023. The purpose of this study was to determine the relationship between the study variables and to establish an educational analysis of the concepts, components and subcomponents in which the reviewed studies are framed. The question is answered : What are the consequences related to critical thinking and the teaching of mathematics from education? Reflecting on and laying the foundations regarding the state of the art around these categories will allow us to identify the components in which the topic is addressed and establish the existing links, in order to analyze the contributions and gaps to be studied.

For the correlation between the variables, the Rho Spearman normality test was used. Regarding the systematic review, the protocol was the search of literature around the categories of analysis, review, extraction and analysis of all the information found. The collection of literature is limited to the Spanish language, during the last five years, the search and review criteria was publications between 2019 and 2023. The readings were systematized in an Excel file, in which some data were recorded, such as; title, author, source, publication date, database, and keywords, depending on the components and subcomponents. The inclusion and exclusion criteria are; that the articles corresponding to the area of education, produced in Spanish, correspond to the categories of the study, published on the basis of those already indicated.

The procedure in both approaches allowed the topics to be analyzed in order to collect similar patterns from the research reviewed, allowing the explanation to be broadened and the results of both perspectives to be complemented. Having a more specific and global perspective around the categories of analysis allowed us to identify similar ideas for discussion and categorization according to the components and subcomponents found in the analysis, and the analysis material was coded to identify emerging points.

## RESULTS AND DISCUSSIONS

## RESULTS OF THE QUANTITATIVE RELATIONSHIP

**Table 1 Correlation of study variables**

| | | | PC | EM |
|---|---|---|---|---|
| Spearman's Rho | Critical Thinking | Correlation coefficient | 1,000 | 0.579** |
| | | Follow-up (bilateral) | . | 0,000 |
| | | N | 103 | 103 |
| | Teaching Mathematics | Correlation coefficient | 0.579** | 1,000 |
| | | Follow-up (bilateral) | 0,000 | . |
| | | N | 103 | 103 |

*Note.* Own elaboration (2024)

After performing an analysis and statistical tests, it is observed that Spearman's compensation coefficient is equal to 0.579, indicating a moderate positive compensation. The P value is 0.000, which is less than 0.05, which means it is statistically significant at the 95% confidence level. Based on these results, we can conclude that critical thinking is moderately related to mathematics education.

**Table 2 Level of Critical Thinking and Mathematics Teaching**

| | | | MS Level | | | |
|---|---|---|---|---|---|---|
| | | | Low | Middle | High | Total |
| PC Level | Low | Recount | 0 | 1 | 0 | 1 |
| | | % of total | 0,0% | 1,0% | 0,0% | 1,0% |
| | Middle | Recount | 1 | 27 | 15 | 43 |
| | | % of total | 1,0% | 26,2% | 14,6% | 41,7% |
| | High | Recount | 0 | 9 | 50 | 59 |
| | | % of total | 0,0% | 8,7% | 48,5% | 57,3% |
| Total | | Recount | 1 | 37 | 65 | 103 |
| | | % of total | 1,0% | 35,9% | 63,1% | 100,0% |

Note. Own elaboration (2024)

## RESULTS OF THE SYSTEMATIC REVIEW

**Table 3 Selection criteria for the systematic review**

| Inclusion and Exclusion Criteria |
|---|
| The articles belong to the Scielo and Scopus databases. |
| Disclosed between 2019 and 2023. |
| Published in Spanish. |
| It corresponds to the field of education. |
| Research is not excluded from the type of approach it takes. |

Note. Own elaboration (2024)

The works analysed are as follows:

**Table 4 Literature reviewed in Scopus and Scielo databases**

| N° | Title | Author(s) year | Fountain | Keywords |
|---|---|---|---|---|
| 1 | Perception of the development of critical thinking skills at the National University of Asunción, Paraguay | Marta Isabel Canese de Estigarribia 2020 | Educational Profiles Scopus | Critical Thinking Higher education Cognitive Ability Mental Process Interpretation Autonomy |
| 2 | Critical Thinking: Conceptualization and Relevance in Higher Education | Mireia Vendrell Morancho, Jesús Miguel Rodríguez Mantilla 2020 | Journal of Higher Education Scopus | Higher education; Students; Critical thinking; Metacognition; Evaluation |
| 3 | Creativity, Critical Thinking and Teamwork in Primary Education: An Interdisciplinary Approach through STEAM Projects | Raquel Casado Fernández, Mirian Checa-Romero 2022 | Complutense Journal of Education Scopus | Does not present |
| 4 | Creating an Instrument for Measuring Critical Thinking Through Mathematics: An Application to First-Year College Engineering Students | Sara Arancibia Carvajal, Matthieu Marechal Imbert, Tomás Neira Navarro and Karelys Abarca Cadevilla 2022 | Journal of Studies and Experiences in Education REXE Scielo | Critical thinking; measuring instrument; mathematics; first year; engineering. |
| 5 | Impact of the Development of Critical Thinking Skills on Reading Comprehension in Basic School Students | Ivette Doll Castillo, Claudio Parra Vásquez 2021 | New Pacific Magazine Scopus | Critical thinking skills, reading comprehension, reading process, textual interrogation, and critical comprehension. |
| 6 | The Development of Critical Thinking as an Attitude in University Education: The Literary Text as a Resource1 | Sara Martínez Mares, Ana Risco Lázaro 2022 | Complutense Journal of Education Scopus | Critical thinking; higher education; democracy; literature |
| 7 | The Concept of Critical Thinking According to Chilean Pedagogy Students | Claudio Heraldo Díaz-Larenas, Carlos Javier Ossa-Cornejo, Maritza Roxana Palma-Luengo, Nelly Gromiria Lagos-San Martín and Javiera Ignacia Boudon Araneda 2019 | Sophia Scopus | Thinking, pedagogy, conceptualization, content analysis, student, teacher. |
| 8 | Diagnosis of Critical Thinking of Primary School Students in Chimbote, Peru | Graciela Pérez-Morán, Janina Bazalar-Palacios and Wendy Arhuis-Inca 2021 | Educare Electronic Magazine Scopus | Critical thinking; childhood; dialogic dimension; substantive dimension; educational institutions. |
| 9 | Design Thinking: Creativity and Critical Thinking in college | Cecilia Latorre-Cosculluela, Sandra Vázquez-Toledo, Ana Rodríguez-Martínez and Marta Liesa-Orús 2020 | Electronic Journal of Educational Research Scopus | Critical Thinking, Innovation, Creativity, Design Thinking |
| 10 | Media and Information Education and Critical Thinking: A Systematic Review | Hibai Lopez-Gonzalez, Luciana Sosa, Lydia Sanchez and Adrien Faure-Carvallo 2023 | Revista Latina de Comunicación Social Scopus | Media and Information Literacy; Disinformation; Education; Critical thinking; Systematic review; Communication; Media education. |
| 11 | Critical thinking skills in university students through research. | Luis Miguel Cangalaya Sevillano 2020 | From the South Scielo | Critical thinking, critical thinking skills, Research, University |
| 12 | Virtual Education in the Critical Thinking of College Students | Carlos Arturo Valencia Morocho 2021 | From the South Scielo | Virtual Education, Critical Thinking, Discussion Forum |

| | | | | |
|---|---|---|---|---|
| 13 | Questions for Inquiry and Activation of Critical Thinking in Early Childhood Education | Inés M. Bargiela, Paloma Blanco Anaya and Blanca Puig 2022 | Science Education Scopus | Critical Thinking, Teacher Intervention, Questions, Inquiry, Early Childhood Education |
| 14 | Analysis, Classification, and Philosophical Foundations of Critical Thinking Models | Angélica María Rodríguez-Ortiz, Juan Camilo Hernández-Rodríguez, Ana Milena López-Rúa, Valentina Cadavid-Alzate 2023 | Sophia Scopus | Critical Thinking, Rationality, Cognition, Pragmatism, Science, Philosophy |
| 15 | Critical Thinking, Creativity, Self-Efficacy and Pedagogical Practice in Educators Peruvian teachers | Boris Jesús Arce-Saavedra and Sheyla Blumen 2022 | Journal of Psychology Scopus | Dispositions to critical thinking, creative-innovative performance, teacher self-efficacy, pedagogical practice, teacher educators |
| 16 | Critical and Computational Thinking Process in Mathematics Learning in Secondary Education | Julia Ángela Ramón Ortiz and Jesús Vilchez Guizado 2022 | Prisma Social Magazine Scopus | Computational Thinking, Critical Thinking, Learning Level, Math Proficiency, Secondary Education |
| 17 | Disposition to critical thinking in university students | Rosario del Pilar López Padilla, Lino Rodríguez Alegre, Haydee del Rosario Ramos Pacheco, Ronald Luis Ramos Pacheco 2022 | Revista Venezolana de Gerencia Scopus | Critical Thinking, Perceived Performance, Academic Self-Efficacy, Academic Performance, College Students |
| 18 | Critical Thinking and Academic Self-Concept from the Correlational Perspective in the Peruvian University Sector | Guido Trujillo Valdiviezo, Lino Rodríguez Alegre, Haydee del Rosario Ramos Pacheco, Ronald Luis Ramos Pacheco 2022 | Revista Venezolana de Gerencia Scopus | Academic Self-Concept, Critical Thinking, Performance Academic, Recognition and Evaluation of Assumptions, College Students |
| 19 | Critical Thinking Skills and Teacher Leadership: A Gender-Sensitive Proposal for Initial Education | Liliana Pedraja-Rejas, Carlos Rodríguez-Cisterna 2023 | Revista Venezolana de Gerencia Scopus | Critical Thinking, Teacher Leadership, Gender, Teacher Education |
| 20 | Design-Based Research in Initial Teacher Education for Integrated Teaching of the Nature of Science and Critical Thinking | Cristina Cobo-Huesa, Ana M. Abril, Marta R. Ariza 2021 | Eureka Journal on Science Teaching and Popularization Scopus | Didactic knowledge of content, design-based research, nature of science, critical thinking, initial teacher training |
| 21 | Integrating Critical Thinking into Science Education in the Post-Truth Era | Blanca Puig, Paloma Blanco-Anaya, Inés M. Bargiela 2023 | Eureka Journal on Science Teaching and Popularization Scopus | Critical thinking, post-truth era, socio-scientific issues, science teaching. |
| 22 | Training for analysis, critical thinking and problem-solving in regional universities | Carlos Emilio García-Duque 2020 | William of Ockham Magazine Scielo | Analysis, Critical Thinking, Problem-Solving Skills, Essential Engagement, Education superior. |
| 23 | Didactic Strategies in the Development of Critical Thinking in Basic Education Students | Luis Alberto Núñez-Lira, Dally Mayer Gallardo-Lucas, Alicia Agromelis Aliaga-Pacore, Jorge Rafael Diaz-Dumont 2020 | Eleuthera Magazine Scielo | Critical thinking, didactic strategies, reasoning, argumentation, decision-making |
| 24 | Critical Thinking and Online Collaborative Learning in College | Madeleine Lourdes Palacios-Núñez, Haymin Teresa Ráez Martinez, Alexander | LACCEI International Multi-Conference for Engineering, | Critical Thinking, Collaborative Online Learning, Correlational Analysis, College Students |

| | | | | |
|---|---|---|---|---|
| | Students: A Correlational Study | Toribio-López and Eduardo Jesús Garcés Rosendo 2023 | Education, and Technology Scopus | |
| 25 | Metacognitive, Critical and Creative Thinking in Educational Contexts: Conceptualization and didactic suggestions | Laura Espinoza Pastén 2021 | School and Educational Psychology Scopus | Metacognition, Critical Thinking, Creativity |
| 26 | Disposition, Critical Thinking Skills, and Academic Success in College Students: A Meta-Analysis | Yordanis Enríquez Canto, Esteban Zapater Ferrer, Giovani Martín Diaz Gervasi 2021 | Complutense Journal of Education Scopus | Systematic review; thought; critical sense; yield; student. |
| 27 | Explanatory causal relationships in science education and their contribution to critical thinking | Nidia Yaneth Torres Merchan, Thiago Henrique Barnabe Corre a, Jordi Antoni Solbes Matarredona 2022 | Investigações em Ensino de Ciências Scopus | Causality, Causal Mechanisms, Science Education, Critical Thinking. |
| 28 | Metacognition in Teacher Professionalization: Critical Thinking in a Mixed Environment | Adriana Margarita Pacheco-Cortés, Elba Patricia Alatorre-Rojo 2018 | Journal of Distance Education Scopus | Teacher training, metacognition, critical thinking, knowledge society |
| 29 | Developing Critical Thinking in Secondary School Students: Design, Implementation, and Evaluation of an Educational Program | Daniel Albertos Gómez, Agustín De la Herrán Gascón 2018 | Journal of Curriculum and Teacher Education Scopus | Science Education, Secondary Education, Assessment, Critical Thinking |
| 30 | Teaching Critical Thinking as Understood by a Group of Teacher Educators | Inés M. Bargiela, Paloma Blanco Anaya, Blanca Puig 2022 | International Journal of the Humanities Scopus | Critical Thinking, Skills, Dispositions, Learning, Learning Environments, Teacher Education, Higher Education |
| 31 | Teacher appreciation to contribute to the development of critical thinking | María Patricia Gómez-Gómez, Sandra Milena Botero-Bedoya 2020 | Eleuthera Magazine Scielo | Development of Thinking, Teachers, Educational Strategies, Teaching Method |
| 32 | The Effect of a Critical Thinking Program on Representation Bias in Pedagogy Students | Carlos Ossa-Cornejo, Alejandro Díaz-Mujica, María Victoria Pérez-Villalobos, Silvia Da Costa-Dutra and Darío Páez-Rovira 2022 | Educational Psychology Scopus | Cognition, professional training, biases, critical thinking, pedagogy |
| 33 | Critical, Complex Thinking and Meaningful Learning in Latin American Education: A Narrative Review | Elisa Martos Humán, Decidero Jhon Rodriguez Álvarez, Carlos Wilder Alvarado Muñoz 2022 | Sociology and Technoscience Scopus | Epistemology, raising awareness, Genuine judgment, knowledge, meaningful learning. |
| 34 | The methodology of Philosophy for Children (FpNN) and the development of critical and creative thinking at school | José Del Carmen Jaimes Morales, Lili María Aaron Zubiria, William Pérez Cantillo 2021 | Journal of Philosophy Scopus | Philosophy for children, school, role of the teacher, critical and creative thinking |
| 35 | The Development of Critical Thinking: A Challenge for Ecuadorian Education | Marielsa López, Edison Moreno, Fernando Uyaguari, Mariela Barrera 2021 | Journal of Philosophy Scopus | Critical Thinking, Excellent Teachers, Educational Strategies |
| 36 | Critical Thinking in Pedagogy Careers | Liliana Pedraja-Rejas, Emilio Rodríguez-Ponce, Francisco Ganga Contreras 2023 | TECHNO Review Scopus | Academics, Critical Thinking, Educational Outcomes, Pedagogy, Teacher Training |

Note. Own elaboration (2024)

In the systematic review, two research questions are presented that allowed us to contrast with the correlational methodology in the discussion. Q1 What thematic components exist in relation to the study variables? About that: Canese (2020) He studied the level of development of the CP in students of the Faculty of Philosophy of the National University of Asunción. A Likert-type test is used to measure such skills. The results indicate an intermediate level of PC development, with challenges in areas such as comprehensive revision of problem-solving proposals and an inclination to tacit acceptance of dominant beliefs. The importance of the CP in the transformation and growth of the human being and his environment is discussed. It is suggested to implement didactic strategies to improve this skill in university students.

Vendrell and Rodriguez (2020) They conducted an analysis of CP as an active, metacognitive process that combines skills, dispositions, and knowledge to formulate reflective and action-oriented judgments. It highlights the importance of developing CP through instruction and practice, as well as its application in difficult and controversial situations in today's world. Being a critical thinker involves questioning information, understanding its social and individual relevance. Promote democratic and bearable participation, evaluating different perspectives and exploring strategies for change.

Married and Checa-Romero (2023) An exploratory ethnographic study was carried out in a primary school in Madrid, analysing the impact of STEAM (Science, Technology, Engineering, Arts and Mathematics) projects on skills such as creativity, PC and teamwork. It highlights the need to enhance skills for future jobs, promoting creative and critical thinking, as well as collaboration. These projects allow students to integrate disciplines, encouraging reflection and critical opinions. Emphasis is placed on the generation of intellectual skills to stimulate the CP, effective communication and self-reflection. Participants highlight the potential of STEAM projects for meaningful learning in primary education.

Arancibia et al. (2022) designed an instrument to measure CP in engineering students through mathematics. Its importance stands out in solving complex problems in engineering. The instrument was applied to 371 first-year students at a Chilean university. Six dimensions of critical thinking were considered. Limitations include applying during the pandemic on a web platform. Workshops were held with experts to validate and fine-tune the questions on the instrument. The results seek to contribute to the improvement of critical skills in engineering students.

Doll & Parra (2021) investigated the impact of a CP skills intervention program on the reading comprehension of elementary school students. The experimental group achieves significant improvements in metacognitive comprehension, moving from the level of development to satisfactory development. The positive relationship between CP and metacognition is highlighted. This skill is defined as a liberating process that allows thinking to be evaluated and analyzed autonomously, avoiding biases and prejudices. Emphasizing self-regulation and constant evaluation of thinking for continuous improvement.

Martinez & Risco (2023) address the importance of CP in university education, highlighting the need to develop cognitive skills and moral attitudes in students. They point out that teachers tend to focus on cognitive skills, neglecting ethical and moral aspects. It aims to recover the moral habit of critical thinking, incorporating criticism into authority and the moral imagination. The use of literary texts as an educational resource is suggested to promote a comprehensive vision of the CP, thus collaborating in the reflective and critical training in the university.

Díaz-Larenas et al. (2019) addresses the complexity of the CP, highlighting its importance in the formation of individuals capable of deep reflection and analysis. The diversity of interpretations of this concept is highlighted, which goes beyond simply judging or criticizing. Key skills such as curiosity, reflection, impartiality, and honesty are mentioned. They highlight the importance of integrating these skills into daily life for an effective PC. It is relevant in human and educational development.

Pérez-Morán et al. (2021) CP was diagnosed in primary school students in Chimbote, Peru. The importance of this skill for the development of their competencies is highlighted. Allowing them to analyze, understand, evaluate, and reflect on information in a deep way. Despite educational efforts, it is noted that a traditional

approach that limits the development of CP still prevails in educational practice. The need for effective educational policies that promote a student-centered quality educational process is highlighted.

Latorre-Cosculluela et al. (2020) studied Design Thinking: Creativity and PC at university. They describe an educational experience where 107 university students designed innovation projects applying Design Thinking. The results show that they managed to design innovative approaches to real problems, fostering collaborative learning and the development of creative and empathetic skills. The improvement in knowledge retention, satisfaction with learning and the acquisition of various competencies are highlighted. This methodological approach enhances CP, innovation and creativity in the training of future university teachers.

López-González et al. (2023)analyze the intersection between media and information literacy and CP. The importance of this education to form citizens capable of critically evaluating information is emphasized. After reviewing 65 articles, it is concluded that the inclusion of media and information literacy in education improves critical capacity, although limitations are pointed out, such as the need to complement it with other approaches. It highlights the need to address disinformation and promote media literacy in the training of critical citizens.

Cangalaya (2020) addresses the importance of CP in university education, connoting its relevance to confronting problems, making decisions and research. It is mentioned that critical thinking, self-directed and self-regulated, requires conceptual considerations and is linked to interpretation, analysis and evaluation. It is proposed that, through research at the university, students develop the qualities of a critical thinker, which will enable them to take responsibility in their academic and professional lives.

Valencia (2021) analyzes the impact of virtual education on the PC of university students during the pandemic. It highlights the importance of academic debate and the Blackboard platform in fostering critical skills, such as argumentation and problem-solving. CP is divided into dimensions such as analysis, inference, argumentation and formulation of solution proposals. The relationship between thought and language, as well as social interaction in the cognitive process, is highlighted. It is concluded that virtual education can enhance the aforementioned professional skills and competencies in higher education.

Bargiela et al. (2022) analyzes the activation of the CP in early childhood education through the questions of a teacher during inquiry tasks. The importance of developing critical thinking skills and dispositions in children from an early age is highlighted. The relationship between the teacher's questions and the practice of critical thinking in children is analyzed, with the aim of understanding how these questions can influence the development of cognitive and personal skills in the infant classroom.

Rodríguez-Ortiz et al. (2023) They approach CP as a process of analysis and evaluation of thought in order to improve it, influenced by Dewey's critical reflection and Kantian judgment. Two cognitive models stand out: the emotional and the scientific, focused on higher-level thinking skills. The importance of training critical thinkers capable of reflecting and acting critically in various contexts is highlighted, although the possible simplification of the concept is warned. The historical and philosophical relevance of this skill, from antiquity to the present day, in education and society is underlined.

Arce-Saavedra and Blumen (2022) examine the relationship between CP, creativity, self-efficacy and pedagogical practice in Peruvian teacher trainers in the San Martín Amazon. Significant direct relationships were found between these variables, where CP and creativity influence teacher self-efficacy and pedagogical practice. Teacher self-efficacy acts as a mediator between critical thinking and pedagogical practice. It is suggested that these relationships be considered in order to improve the capacities of teacher educators and, therefore, the quality of teaching in this region.

Ramón y Vilchez (2023) analyze the importance of the PC and computational in the learning of mathematics in secondary education. They highlight that the promotion of the PC in the educational process stimulates the autonomy and maturity of the student, significantly influencing the resolution of mathematical problems. At the same time, they possess a level of PC that intervenes in mathematical learning. In addition, the incorporation of computational thinking into the school curriculum is advocated to enhance analytical skills from an early stage. Digital technology is presented as an essential resource in today's mathematical education.

López et al. (2022) analyze the disposition to the PC in international business students, highlighting its importance in decision-making and problem solving. CP is defined as an intentional, self-regulating process that involves interpretation, analysis, evaluation, and inference based on evidentiary considerations. It examines how academic institutions promote this skill in students, focusing on reflection, reasoning, and the generation of strategies to address complex situations. It highlights the need to cultivate critical thinkers to achieve informed decisions and effective learning in academic and professional settings.

Trujillo et al. (2022) The study analyzes the correlation between CP and academic self-concept in International Business students at UNMSM in Peru. A significant relationship was found between PC readiness and perceived performance, as well as academic self-efficacy. We found no evidence of a significant relationship with academic performance. The importance of promoting CP in professional training is highlighted, suggesting the implementation of programs that stimulate this skill to prepare students for decision-making in complex environments.

Pedraja-Rejas and Rodríguez-Cisterna (2023) They propose linearly to promote the development of CP in teacher education to address biases, stereotypes and gender roles in society. Six orientations for the training of teachers with a gender perspective and CP skills are presented, highlighting the importance of education in this process. It is emphasized that critical thinking is fundamental to social transformation, allowing individuals to reflect, question, and evaluate autonomously. It underlines the need to address these issues responsibly and with commitment in order to move towards a more just and equitable society.

Cobo-Huesa et al. (2021) address the importance of integrating the Nature of Science (Cr) and CP into science education, highlighting the need for research-based methodological strategies to train teachers. The relevance of contextualized and dynamic teaching that enhances the functionality and transversality of the LoC and CP is highlighted, as well as the contextualized and social construction of the Didactic Content Knowledge (CoC). Emphasis is placed on the ability of the PC to improve thinking in decision-making and judgments, which is fundamental for understanding and validating scientific knowledge.

Puig et al. (2023) generated didactic designs to integrate the PC into science education in the post-truth era. It highlights the importance of the CP in today's scientific literacy. These designs should combine practical and metacognitive elements to foster CP in post-truth contexts. It emphasizes the need to think independently, question assumptions, evaluate evidence from diverse sources, and be willing to change one's mind based on solid evidence. The article underlines the relevance of integrating CP into science education in order to train citizens capable of facing the challenges of today's society.

García-Duque (2020) It deals with training for analysis, CP and problem solving in the regional universities of Carlos Emilio García-Duque. It analyzes the lack of materialization of the essential commitment to education in Colombian regional universities. It highlights the importance of the CP as a fundamental mechanism for intellectual progress, promoting the generation of new ideas, constructive debate and the confrontation of positions. Tips are suggested to improve academic training, review pedagogical practices, and promote critical examination in the classroom, with the aim of strengthening students' analytical and problem-solving skills.

Núñez-Lira et al. (2020) Didactic strategies for developing CP in high school students in Ocros were evaluated. The sample included communication teachers in educational institutions in the Ancash region. Instruments such as logs and interviews with specialists were used. The results highlighted the importance of argumentation and decision-making in the CP process. The conclusions emphasized the need to promote a holistic view of students when issuing conclusions about problematic situations, highlighting the relevance of guiding them in the selection and processing of information in a digital environment.

Palacios-Núñez et al. (2023) They determined the relationship between critical thinking and collaborative online learning in college students. He used a quantitative approach with a sample of 122 students from a private university in Lima. The results showed a strong correlation between critical thinking and collaborative online learning, highlighting the importance of teaching strategies that foster these skills. It was concluded that collaborative online learning can contribute significantly to the development of critical thinking in virtual educational environments.

Espinoza (2021) It discusses the importance of metacognitive, critical, and creative thinking in learning and academic performance. It is based on studies in psychology and cognitive neuroscience. The need to stimulate these mental processes in educational contexts to form reflective learners is highlighted. It is suggested to encourage social interaction between students to enhance creative thinking. It concludes that these types of thinking are fundamental to problem-solving and the continuous transformation of thinking, both in academic settings and in everyday life.

Enriquez et al. (2021) A meta-analysis was conducted that investigated the relationship between disposition, PC skills, and academic success in college students. We included 32 studies with 4962 participants, mostly from the USA and Health Sciences. The random-effects model was used to analyze the correlation between CP and academic success. A moderate positive correlation was found between these variables. It was concluded that this skill is crucial for university academic performance, highlighting the importance of developing these skills for educational success.

Torres et al. (2022) analyze the importance of causal relationships in CP in science education. It aims to explore how these relationships contribute to the development of critical competencies in students. The sample includes research by Torres, Solbes and other relevant authors in the field. A detailed literature review methodology is used. The results highlight the need to understand causal relationships in order to analyze problems in depth and promote CP. It is concluded that these relationships are fundamental to question arguments, make informed decisions and actively participate in society.

Pacheco-Cortés and Alatorre-Rojo (2018) A series of studies were conducted to analyze CP in teachers during a course-workshop, using a mixed qualitative-quantitative approach. Written reflections were collected from the participants and content analysis and basic statistics were applied. The results showed that the most frequent characteristic was accuracy, while the least frequent was responding appropriately to the feelings and knowledge of others. It highlights the importance of training teachers in the conscious development of CP to support their students.

Albertos and De La Herrán (2018) address the development of CP in secondary school students through a program based on scientific competence. The sample includes students with difficulties. The methodology focuses on practice with scientific methodology. The results show improvements in comprehension, information search, and PC. The need for follow-up and help from the teacher is highlighted. The conclusions highlight the importance of the methodology used to improve critical thinking in problematic situations.

Bargiela et al. (2022a) It analyzes the conceptualization of critical thinking by teacher educators and the learning environments designed. Five semi-structured interviews and content analysis were used. The results revealed that CP is implicitly promoted through active learning in real-world contexts. Challenges were identified in the design of learning and assessment environments. The importance of promoting CP from a practical and applied perspective in higher education is highlighted.

Gómez-Gómez and Botero-Bedoya (2020) analyze teachers' appreciation of CP in education. Using a qualitative approach and semi-structured interviews, the convergence between theory and practice in the promotion of CP in the classroom is evidenced. Teachers conceive of this skill as a fundamental cognitive process for analysis and reflection. The importance of educational strategies that foster analytical, inquiry and reflection skills in students is highlighted. The results underscore the need to strengthen CP in academic training to promote comprehensive competencies in students.

Ossa-Cornejo et al. (2020) investigated the impact of the PENCRIT critical thinking program on representation bias in pedagogy students. The sample included university students of pedagogy. A quasi-experimental methodology was used. The results showed an improvement in representation bias after the implementation of the program. Limitations were identified in the reliability of the instrument and in the study design. We suggest the need for future research to improve strategies for reducing bias in the scientific reasoning of professionals in training.

Martos et al. (2022) The researchers analyze CP in Latin American basic education, using a sample of 17 academic resources from databases such as Scielo and Scopus. The methodology includes the systematic review

of the integrated critical and complex thinking matrix, with a focus on meaningful learning. The importance of the student's self-management of knowledge and the use of the environment to acquire new knowledge is highlighted. The results highlight the need to promote CP in education. In conclusion, the importance of integrating this skill into educational practice to improve meaningful learning is emphasized.

Jaimes et al. (2021) highlight the Philosophy Program for Boys and Girls (FpNN) as a tool to strengthen PC and creativity in school. It is based on Lipman's methodology, encouraging inquiry and philosophical dialogue among students. They highlight the importance of developing argumentative, ethical and political skills from an early age. They break with the traditional idea that children cannot philosophize and rely on Piaget's studies. They conclude that it is essential to stimulate interest in reading and curiosity from early education in order to cultivate skills that endure throughout life, thus challenging the apathy and disinterest of contemporary students.

López et al. (2021) analyzes the development of CP in Ecuadorian education through the perspective of five outstanding teachers. Using in-depth interviews, we explore the strategies employed by teachers to foster critical thinking in students. The results reveal the diversity of approaches according to the teachers' disciplines, highlighting the importance of promoting reasoning, analytical and problem-solving skills. The need to overcome structural barriers in the education system in order to enhance CP is highlighted.

Pedraja-Rejas et al., (2023) analyze the relationship between the characteristics of the academic body, the development of CP in students and the educational results in teacher training. Using secondary sources, a conceptual model is constructed. The importance of such a skill in higher education and its impact on academic achievement is highlighted. There is evidence of a low self-perception of CP in workers. It is proposed that fostering CP in students benefits problem-solving, creativity, and meaningful learning. The study seeks to improve the quality of teacher training through policies that encourage the development of this skill.

Answering the second question: Q2: What are the main thematic components and subcomponents of CP and MS? The topics in the table are directly and indirectly associated with the study variables from a cross-sectional view in education. The organized contents are feasible for discussion, however, it constitutes an approximation to the tendencies in which the studies involved with the categories of analysis are oriented.

**Table 5 Thematic components in the study of CP and MS**

| Components | Sub-Rapporteurs | Topics according to the components assumed by the articles | | |
|---|---|---|---|---|
| | | PC | | EM |
| Social development | Citizenship education | - Moral reasoning<br>- Cognitive skills<br>-Interpersonal skills<br>- PC Skills<br>- Critical thinking<br>- PC Features | - Promotion of creativity<br>- Promotion of innovation<br>- Real-world problem solving | - Social interaction<br>- Active participation<br>- Science education<br>- Importance of training<br>- Cognitive neuroscience<br>- Computational thinking |
| | Development of science | - CP and complex and controversial situations<br>- Critical Citizenship<br>- Environmental sustainability<br>-Climate change<br>- Reading comprehension<br>- Literary Texts -- - Self-Regulation<br>- Moral attitudes<br>- Criticism of authority<br>- Moral imagination<br>- Enriching democracy<br>- Design thinking | - Media education<br>- Information education<br>- Basic Skills<br>- Media literacy<br>- PC Models<br>- Philosophical Foundations of the PC<br>- PC Gender Biases and Stereotypes<br>- Gender perspectives<br>- Social transformation<br>- Job success | - Integration and the nature of science<br>- Ability to question assumptions |
| Educational Praxis | Basic or elementary education | - Didactic strategies<br>- Motivation and metacognition<br>- Metacognitive processes<br>- STEAM Projects<br>- Teamwork | - Learning environments<br>- PC-friendly environments<br>- Creativity and innovation | - Mathematical thinking<br>- Creative thinking<br>- PC readiness<br>- Blended learning environments<br>- Problem solving |

| | | | | |
|---|---|---|---|---|
| | **Higher education at the university**<br>**Initial Teacher Training (FID)** | **- Effective communication**<br>**- PC readiness**<br>**- PC in Early Childhood Education**<br>**- PC in university students**<br>**- PC in an academic context**<br>**- PC in a work context**<br>**- Impact of the PC on the personal**<br>**- Impact of the PC on the professional**<br>**- PC Evaluation**<br>**- PC in the 21st century**<br>**- Meaningful learning**<br>**- Authentic learning**<br>**- Collaborative learning**<br>**- Active learning**<br>**- Virtual education**<br>**- Virtual platforms**<br>**- PC & Language Connection** | **- Teacher self-efficacy**<br>**- Teacher training**<br>**- Teachers' thinking styles**<br>**- Academic self-concept**<br>**- Teacher Leadership**<br>**-Higher education**<br>**-Evaluation**<br>**-Self-evaluation**<br>**- Critical examination**<br>**- Classroom management**<br>**- Challenges of Peruvian education**<br>**- Motivating didactic strategies**<br>**- Virtual environments**<br>**- Digital literacy**<br>**- Academic success** | **- PC dimensions; interpreting, inferring, arguing, analyzing, hypothesizing, solving problems, and logical reasoning**<br>**- Complex issues**<br>**- Reasoning and argumentation**<br>**- Academic performance**<br>**- Didactic PC layouts** |

Note. Own elaboration (2024)

## DISCUSSION

These results arise from the correlation and systematic review of CP and MS. In relation to the overall objective, Spearman's Rho rating of 0.579 indicates a moderate positive association, suggesting that greater PC development by teachers translates into better performance in mathematics teaching. The cross-analyses between the variables show that 48.5% of the teachers achieve a high level in this aspect. This finding is consistent with the study of Gamboa (2022), which concludes that the teaching of mathematics and the PC are connected through knowledge and the use of heuristic procedures for teaching. On the other hand, in MS, employing problem-based strategies improves critical thinking in students (Bermúdez, 2021).

In the Specific Objective One, with respect to the analysis of teachers' CP, the results show that the teachers surveyed have a high level (57.3%) of CP. When looking at other studies such as the one by Bezanilla et al. (2018), it is noted that people who exhibit critical thinking demonstrate analytical and reasoning skills, which has a direct impact on education and, in a practical way, on the teaching and learning processes. On the other hand, differences are recognized in the conceptualization and evaluation of this ability, which are closely related to cognitive and metacognitive dispositions, abilities (Ossa-Cornejo et al., 2017). Therefore, the analysis focuses on the importance of teachers developing CP skills for MS. This should make it possible to associate this quality with its teaching. A teacher who lacks critical thinking will be limited in his or her ability to question what he or she teaches.

In relation to the second specific objective, when examining MS, the findings show that 63.1% reach a high level. This suggests that teaching is based on meaningful situations and everyday problems with direct relevance to daily life. For Panes-Chavarría et al. (2018), this is linked to the context, to apply them in the experience of mathematics. Good teaching optimizes the processes involved in teaching and learning (Valbuena-Duarte et al., 2021). Undoubtedly, the use of strategies in the teaching of mathematics contributes significantly to the development of critical thinking (Ojose, 2022).

The third specific objective focuses on knowing the features of the dimensions of teachers' critical thinking. In the Logical Dimension, teachers were asked whether, in teaching, they analyze texts, draw conclusions, identify errors in a text, recognize underlying assumptions, and determine the correct hypotheses or answers to the problems posed. Most responded that they do these activities quite often, suggesting that they don't always do them when teaching math. This dimension is related to the teacher's adoption of relevant sequences in teaching, which, according to the Torres-Miranda (2020), contributes to the understanding of knowledge in a reality in which differences are clarified.

As for The substantive dimension, respondents were asked whether they identify main and secondary ideas, recognize responses as part of learning, assess their quality, identify assumptions, and make justified conclusions. Teachers indicated that they use these procedures quite frequently (53.4%). This suggests that algorithmic methods in mathematics teaching have not yet been fully consolidated (Remache-Bunci, 2019).

The Contextual dimension It is related to the ability of teachers to explain an approach in simple language, to make contrasts, to differentiate between a proven issue and an opinion, and to gather evidence. The results show that 42.7% of teachers carry out these activities quite frequently. This indicates that teachers have not yet fully appropriated the educational reality, either due to lack of interest or laziness. This dimension requires teachers to recognize and understand the context in which the learning experience takes place and to use available resources (Estévez et al., 2021).

In the Dialogic dimension, asked whether they recognize unclear communication, whether it is persuasive, whether they detect differences, ask pertinent questions, and present ideas in a concise manner. A total of 37.9% of teachers indicate some of the time. This suggests that, from the PC perspective, teachers show a lack of openness to listening to their students. This dimension requires teachers to explore and examine learners' thoughts, considering their views (Remache-Bunci, 2019).

As for the Pragmatic dimension, teachers were asked if they evaluate definitions, classify information, practice, and distinguish between sound and gaseous arguments. 42.7% responded that they carry out these activities quite frequently. This indicates that teachers often employ strategies to achieve results and solve problems, thus ensuring learning (Ojose, 2022).

Regarding the dimensions of MS, the research from a quantitative perspective considers five dimensions. The Dimension Familiarization with the problem, the questions asked have to do with whether you start your classes with a problematic situation, allow them to become familiar with the problem, ask questions about the problem and help activate previous knowledge? A majority of 37.9% indicate that they always allow students to become familiar with the problem. Therefore, it is essential to formulate questions that help students approach the math problem and identify the processes needed to solve it (May, 2015).

As for the search and execution of strategies, teachers were asked if they allow students to investigate and ask questions, give them time to come up with answers, collaborate appropriately on mathematization, and identify problems to help them overcome them. 36.9% indicated that they perform the actions sometimes when teaching mathematics. This indicates that teachers are not in the habit of seeking and applying effective strategies in the teaching of mathematics. According to Polya (1989), students must anticipate and practice exercises, operations, or problems that they can solve, and for this they need to know strategies that allow them to approach the approaches effectively.

Respect to socialize their representations, 37.9% of teachers indicated that they only sometimes ask students about their representations, clarify their doubts, guide them in difficult situations and evaluate them periodically. This suggests that teachers do not take a pragmatic approach that allows children to concretely represent resources and arrive at symbolization in mathematics (MINEDU, 2015).

As for the Reflection and formalization, 46.6% of the teachers indicated that they regularly talk to students to find out how they found the solution, present their conclusions, socialize their actions and encourage them to face new situations. This allows students to handle a structured sequence of methodologies and resources to tackle math problems (MINEDU, 2015). Which, according to Polya (1989), gives them the confidence to tackle similar problems with ease.

Finally, with respect to the Raising other problems. The results show that 36.9% indicate quite frequently that; It encourages children to pose problematic situations that come from their reality, boosts their autonomy, encouraging reflective practice and using their knowledge. This implies the mastery of mathematical knowledge and language (MINEDU, 2013). According to Blanco et al. (2015), contextualization should be considered depending on the situations. In addition Monroy (2014) It highlights the importance of integrating quantitative and qualitative data in mathematical problem solving.

This passive relationship between CP and MS indicates gaps in the analyses by dimensions. It can be noted that didactic processes are involved and assume grounded sequences that require critical thinking. This skill in teaching mathematics is crucial because it allows students to analyze, evaluate, and solve problems in a logical and coherent manner. It fosters deep understanding, effective reasoning, and the ability to apply mathematical knowledge to real-world situations, thus improving learning and decision-making.

The analysis of the study from the perspective of the systematic review on CP and MS. Regarding the social development component. The first sub-component: citizenship education. The research analyzes the importance of cultivating critical, ethical, and reflective skills in the formation of citizens capable of actively participating in society, discerning relevant information, and contributing to the development of informed and engaged communities. Meanwhile, in the development of science, academics highlight the importance of critical, metacognitive and creative thinking in academic learning, emphasizing the need to stimulate these mental processes in educational environments. The relevance of understanding causal relationships to promote CP in science education and educational practice is highlighted, thus improving meaningful learning and forming citizens capable of facing the challenges of today's society.

On the other hand, in the component of educational praxis, in the subcomponent of basic or elementary education, the analysis highlights the importance of education in the development of fundamental skills such as critical thinking, creativity, problem-solving and collaboration in students. Emphasis is placed on the need to implement effective didactic strategies, intervention programs, and projects to enhance meaningful learning and CP from early stages. In addition, the relevance of promoting a holistic view of students when facing problematic situations is highlighted, as well as the importance of overcoming structural barriers in the educational system to enhance critical thinking.

Regarding university higher education, the contributions of the articles highlight the importance of CP in universities, focusing on the development of cognitive, ethical and moral skills in students. It highlights the need to balance the focus on cognitive and ethical skills, promoting reflection, criticism of authority, and moral imagination. The relevance of the CP in complex problem solving, decision-making and research is underlined. The positive correlation between critical thinking and academic success is emphasized, highlighting the importance of cultivating critical thinkers to achieve informed decisions and effective learning in academic and professional settings.

Regarding initial teacher training (IDF), its relevance in the development of critical thinking, which is crucial to improve the teaching of mathematics, is highlighted. It is highlighted that the PC promotes problem solving, decision-making and creativity in future teachers. Integrating this skill into teacher training makes it possible to address biases, stereotypes and gender roles in society, promoting autonomous reflection and evaluation in teaching. Improving the quality of teacher education through the promotion of CP in students benefits meaningful learning and the capacity of trainers to transform pedagogical practice.

## CONCLUSION

In quantitative analysis, the research corroborates that there is a moderate link between CP and MS. Teachers primarily make inferences, calculate probabilities, solve problems, and make decisions when teaching. This involves creating socio-culturally relevant activities that address real problems, using logic and reasoning in daily life. Thus, students move away from the simple memorization of conventional formulas and rules, giving mathematics a practical meaning in their lives. The study should be noted that teachers, with respect to the logical, substantive, contextual, dialogic and pragmatic dimensions, employ authentic procedures to stimulate CP, which means that it is addressed quite regularly. Regarding how he teaches mathematics in the assumed dimensions; The results are evidence that they make quite frequently. What would be very important to directly study the effect of PC and how students learn to contrast and discuss the findings.

Critical thinking in mathematics teaching is vital as it fosters analytical and problem-solving skills in children. It allows them to apply logic and reasoning to real situations, developing a deep and practical understanding of mathematical concepts. Not only does this improve their academic performance, but it also prepares students for informed decision-making in everyday life.

Qualitative analysis connotes the importance of citizenship education and requires critical, creative and media skills. Highlighting the importance of educating thoughtful and engaged individuals for informed participation in society. For this reason, the development of science requires the promotion of PC, metacognitive and creative in educational environments to train reflective learners and citizens capable of facing current challenges. Basic education is key to developing the skills referred to above from childhood, promoting meaningful learning and preparation for future academic and work challenges. This determines academic and professional success, promoting cognitive, ethical, and moral skills in students. CP in teacher training is essential to improve the teaching of many areas, especially mathematics, and to promote autonomous reflection in future educators.

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