

DEVELOPMENT OF CRITICAL THINKING IN ENGINEERING STUDENTS

DESENVOLVIMENTO DO PENSAMENTO CRÍTICO EM ESTUDANTES DE ENGENHARIA

DESARROLLO DEL PENSAMIENTO CRÍTICO EN ESTUDIANTES DE INGENIERÍA



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ABSTRACT: The article explores the potential of technology to foster the development of critical thinking as an essential condition for students to acquire professional competencies geared toward innovation. Considering the current educational landscape, emphasis is placed on the need for educators to account for the influences of contemporary digital transformation trends in the educational process. The study aims to evaluate the effectiveness of different pedagogical methods and analyze their impact on student's critical thinking skills throughout the learning process. The research adopts a mixed-methods approach, utilizing theoretical and empirical methods, and was conducted with 160 students from the Industrial University of Tyumen. The results indicate that group work (78%) and thematic research are the most effective and preferred methods for developing these skills. The conclusions presented in the study can be utilized by educators teaching humanities and technical disciplines in educational institutions.

KEYWORDS: Critical thinking. Education quality. Systemic thinking. Innovation competencies.

RESUMO: O artigo aborda o potencial da tecnologia para fomentar o desenvolvimento do pensamento crítico como condição essencial para os estudantes adquirirem competências profissionais voltadas à inovação. Considerando o cenário atual da educação, enfatiza-se a necessidade de que o professor considere as influências das tendências contemporâneas de transformação digital no processo educacional. O objetivo do estudo é avaliar a eficácia de diferentes métodos pedagógicos e analisar seu impacto nas habilidades de pensamento crítico dos alunos ao longo do processo de aprendizagem. A pesquisa adota uma abordagem mista, utilizando métodos teóricos e empíricos, e foi realizada com 160 discentes da Universidade Industrial de Tiumen. Os resultados indicam que o trabalho em grupo (78%) e a pesquisa temática são os métodos mais eficazes e preferidos para o desenvolvimento dessas habilidades. As conclusões apresentadas no estudo podem ser aproveitadas por educadores que atuam no ensino de disciplinas das áreas de humanidades e técnicas em instituições educacionais.

PALAVRAS-CHAVE: Pensamento crítico. Qualidade da educação. Pensamento sistêmico. Competências de inovação.

RESUMEN: El artículo aborda el potencial de la tecnología para fomentar el desarrollo del pensamiento crítico como una condición esencial para que los estudiantes adquieran competencias profesionales orientadas a la innovación. Considerando el panorama actual de la educación, se enfatiza la necesidad de que los docentes tengan en cuenta las influencias de las tendencias contemporáneas de transformación digital en el proceso educativo. El objetivo del estudio es evaluar la eficacia de diferentes métodos pedagógicos y analizar su impacto en las habilidades de pensamiento crítico de los estudiantes a lo largo del proceso de aprendizaje. La investigación adopta un enfoque mixto, utilizando métodos teóricos y empíricos, y se realizó con 160 estudiantes de la Universidad Industrial de Tiumen. Los resultados indican que el trabajo en grupo (78%) y la investigación temática son los métodos más eficaces y preferidos para el desarrollo de estas habilidades. Las conclusiones presentadas en el estudio pueden ser aprovechadas por educadores que enseñan disciplinas en las áreas de humanidades y técnicas en instituciones educativas.

PALABRAS CLAVE: Pensamiento crítico. Calidad de la educación. Pensamiento sistêmico. Competencias de innovación.

Introduction

The pursuit of high-quality education and the development of innovative skills are among the main goals of education. Among the nine categories of universal competencies that permeate all educational spheres, systemic and critical thinking stands out as a central element.

Critical thinking is a skill that enables individuals to analyze and evaluate information present in media messages, understand the motives behind them, identify and reveal hidden intentions and stereotypes, and make informed decisions based on the information available. Based on an analysis of scientific literature and psychological research, **critical thinking is understood as a concept integrated into prevailing educational theories**, such as productive, problem-based, creative, logical, and systemic theories.

In the global scientific field, critical thinking is widely discussed in psychology and pedagogy and is addressed in works by authors such as Berdnikova (2009), Eferova (2010), Lindsay, Hull, and Thomson (2001), Minkina (2000), Paul (1990) and Halpern (2001). It is also referenced in the work of 20th-century psychologists such as Vygotsky, Piaget, and Bruner (Facione, 2015). In Dewey's writings, critical thinking is described as a complex activity (Stanford Encyclopedia of Philosophy, 2018), while K. Popper introduced the concept to pedagogical science in the 1950s. Popper introduced the concept to pedagogical science in the 1950s. Relevant studies on the subject have also been conducted by Zair-Bek and Mushtavinskaya (2011), among others.

The critical thinking approach has been explored from various perspectives, including creativity (Boyazitova; Belous; Romashchenko, 2016), self-actualization, and independence, with contributions from authors such as Bogoiavlenskaia, Brushlinskii, J. Guilford, Maslow, Matiushkin, Morozov, Rakhimov, Rogers and Rubinstein (Plotnikova, 2015).

In essence, it is reflective and aimed at studying one's thinking (Yakunina, 2019). It is based on a system of mental states, properties, and processes aimed at evaluation. The formation and development of critical thinking, as a multifaceted process of reflection, is the basis of creative thinking. These two types of thinking often develop in tandem, allowing for the consolidation of a style geared toward achieving effective results. These ideas are reflected in the works of Shcherbakova, Bykovsky, Vasilenko, Korgagin, Nikulin, Shepilov, Shnyakin, and Yudin (2023).

Despite the many conceptual approaches, critical thinking is often associated with scientific thinking and higher-order thinking. There is a consensus on its essence, defined as "*a system of self-regulated and intentional judgments used to interpret, analyze, evaluate, draw*

conclusions and explain reasoning based on evidence of a conceptual, methodological, criteriological or contextual nature". This definition, together with the six main cognitive skills of critical thinking proposed by Facione in 1990 (2015), serves as the basis for this research.

The models considered by the scientific community to be the most valid are the *Delphi*, the *American Philosophical Association*, and that of *P. Elder*. Volkov also highlighted these two models as the most advanced and useful practical criteria (YAKUNINA, 2019). In our research, we analyzed the formation and development of critical thinking skills in students at different stages of learning, subjected to various techniques and methods, which were then interpreted in the light of the seven main cognitive skills: interpretation, analysis, evaluation, formulation of conclusions, explanation, self-regulation and development of critical thinking skills.

According to experts, the most effective form of teaching focused on developing students' critical thinking is collaborative learning, which involves working in small or large groups. When facing a challenge, this technique encourages the activation of prior knowledge by working with facts and stimulating creative activity - possibly through the use of Bloom's Cube. This approach also makes it possible to assess the student's level of intellectual development: "simple" questions address accessible content in the initial phase of presenting the challenge, while "complex" questions in the reflection phase show the depth of the student's understanding of the content.

Another important way of working is through group discussions. This technique involves the open exchange of opinions, statements, and ideas on the problems and topics discussed. Group discussions require prior preparation on the proposed topics or issues, which must be announced in advance. For greater effectiveness, it is advisable to organize these discussions in smaller groups of 7 to 12 people. This type of activity teaches students self-control skills, a culture of debate, tolerance, and respect for different points of view.

A third recommended strategy for developing critical thinking is the use of master classes, an active, practice-oriented learning modality. These lessons involve practical exercises aimed at developing skills such as observation, questioning, comparison, recognition, research, and discussion.

In addition, the case study method proves to be an effective technique. Case studies are used to analyze specific situations, teaching students to deal with information, identify key points, understand problems, describe details, investigate issues comprehensively, and find primary and alternative solutions. Teamwork in this context stimulates active discussions about possible solutions and generates a practical result. In addition, group work strengthens students'

cooperation skills and fosters the development of independent opinions and analytical and evaluative thinking.

The methods of *clusters* and insertions focus on working with texts illustrated in the form of semantic units. These methods prove highly effective in the challenge and reflection stages. It also promotes the development of critical thinking in university students, improving their ability to structure, systematize, and summarize material. These techniques are commonly applied in the challenge and comprehension phases and are based on the student's previous experience, so it is in the initial training phase (challenge) that the motivation for learning is established.

In terms of importance, the skills of working with texts are attributed to analytical tables, because the information obtained provides students with the knowledge and skills necessary for more agile adaptation and effective communication in modern society. In the professional context, these skills allow students to feel more fully realized, as the application of this technology aims to intentionally shape and develop the personal qualities that are essential for the contemporary individual. Modernity demands that professionals have qualifications, demonstrate an active attitude, mobility, sociability, and the ability to improve their attitudes, build a successful life, and chart a continuous path for their personal development.

Methods

The study used a combination of theoretical and empirical research methods to investigate the development of communication skills in engineering students. The methods aimed to evaluate the effectiveness of the teaching approaches and the university students' perception of their learning experience. The empirical research was carried out at Tyumen Industrial University.

Theoretical Analysis

The theoretical basis of the research was based on an in-depth review of the academic literature on the development of critical thinking in higher education. Articles were searched in the main academic databases, such as Scopus and Web of Science. The search strategy used the following key terms: "critical thinking in higher education", "pedagogical methods for critical thinking", and "development of cognitive skills in engineering students".

The theoretical analysis aimed to define what critical thinking is, its key components (interpretation, analysis, evaluation and self-regulation) and its relevance to engineering education. The study also considered different pedagogical approaches used to develop these skills, with special emphasis on group discussions, thematic research, and the use of analytical tools such as *clusters* and tables.

Empirical Analysis

The empirical study aimed to evaluate the practical effectiveness of different learning methods in developing students' critical thinking skills. The socio-psychological research was conducted at Tyumen Industrial University in order to identify problem areas in the development of critical thinking. A questionnaire was administered to 160 students (110 men and 50 women).

Participants were asked to evaluate the relevance of various psychological techniques. The quantitative data collected from the questionnaire answers was processed using statistical software to calculate frequencies, percentages, and averages. Descriptive statistics were used to summarize the percentage of students who preferred each method, as well as their evaluations of the effectiveness of these methods in developing critical thinking.

The results were classified into three categories: low, medium, and high proficiency, and analyzed to identify the areas where students had difficulties or showed strengths.

Results

The results of the survey suggest the following conclusions:

1. Students' understanding of the concept of "quality education" and the distinction between the terms "knowledge" and "skill": only 30% of students associated the concept of "quality education" with theoretical knowledge, 33% perceived it as the ability to carry out practical activities based on the chosen theoretical framework, and 37% recognized the equivalent importance of theoretical knowledge and practical skill.

2. Preferred learning methods in practical classes: in the first place, group work (both small and large groups), with 78% preference. Case studies came in second place with 72%, followed by discussions with 37%, and in fourth place, *master classes* with 10%. The *clusters* and table methods occupied the last positions in the ranking, which can be attributed to the

intensity of the preparation work and the time required to organize and conduct the lessons using these techniques.

3. University students' assessment of the importance of the methods used to develop critical thinking skills: group work was perceived by the participants as an ineffective learning method, due to its frequent use, which makes it predictable and loses its appeal. When the composition of the groups remains unchanged, the established work algorithms no longer generate interest. However, this technique is still considered useful for developing thinking and for training communication skills, tact, and composure.

As pointed out by the students, group discussions ranked next and were recognized as a highly valuable method. They emphasized its importance in forming a comprehensive view, finding reasoned objections or answering them, developing skills such as active listening, understanding, identifying the main points, and improving emotional control.

The *master class* method has been identified as an essential approach for developing the skills required by contemporary society. The students pointed out that the exercises and steps related to this method are often incorporated. Master classes promote the strengthening of communication skills, especially since behavioral patterns tend to change during group work. The university students also highlighted the case study method as fundamental for developing skills such as leadership, determination, sociability, and the ability to analyze large volumes of information, make objective decisions under stressful conditions, and deal with a lack of complete information.

The method of *clusters* aroused the students' interest, being well known from school practice, with its application and mastery expanded in independent work. Most of the students believed that this method taught them how to structure the material, facilitating a better understanding of the content. In addition, it proved useful in formulating answers and communicating logically and coherently, which is particularly relevant in the reflection stage.

The table method was also used in the educational process. Among the most commonly used types are: "For and Against," "What I Know/What I Want to Know/What I've Learned" (KWL), "Positive/Negative/Interesting" (PMI), and the concept table. This technique has proved effective in arousing students' interest in the material, helping them synthesize and systematize information, promoting a careful approach to teaching texts, and facilitating the drawing of conclusions.

The students showed an interest in techniques and methods that improve social and professional skills. In the context of training and developing critical thinking, these practices

have contributed significantly to re-evaluating the material studied and recognizing its potential value.

Evaluation of training and development of critical thinking skills

The study included an analysis of the formation and development of critical thinking skills among the participants based on key indicators such as the ability to interpret educational information, analyze, evaluate, formulate ideas, and exercise self-regulation.

The results indicated that 42% of the students had a low ability to interpret educational information, 45% reached an average level, and only 13% demonstrated a high level. These figures show difficulties in interpreting graphic material, explaining facts and events, and organizing information into events and categories in a structured way.

With regard to analytical skills, such as the ability to identify essential aspects and construct the logic of arguments, 16% of participants achieved a high level, 37% showed average performance, and 47% demonstrated a low level.

Competences related to evaluation and formulating conclusions were classified as high by 21% of respondents, medium by 54%, and low by 25%. These results indicate difficulties in carrying out analytical activities, such as arguing, identifying judgments, formulating reasoned conclusions, predicting the consequences of events, constructing explanations based on evidence, and developing hypotheses.

Finally, an average level of critical thinking was observed in 49% of the students in the explanation indicator and 40% in the self-regulation indicator. These results indicate that although the students have a certain ability to analyze and evaluate statements, logical constructions, and reasoning, there is still potential to improve these skills.

Final considerations

Below-average scores in any of the structural components of critical thinking indicate the need to supplement the educational process with techniques and methods focused on developing these skills.

The results indicate that students positively evaluate the learning approaches and methods that help them master the specific knowledge of the subjects with greater quality.

Diverse techniques and methods encourage active participation in discussions and master classes, promote the application and development of teamwork skills, and ensure effective interaction between participants in the educational process.

The implementation of the method of working with tables in the "Legal Culture" course proved to be particularly advantageous. It helped to organize the material studied and offered a practical way of systematizing and summarizing. The discussion methods and the work in large and small groups enabled the students to formulate and defend their opinions, demonstrating erudition and leadership skills, which ensured that the main educational objectives of the subject were achieved. However, the cluster method was the least used. Even so, the students recognize its potential for developing logical thinking and helping them articulate their thoughts and think coherently.

These results lead us to conclude that the application of critical thinking technology in the university education process offers significant opportunities. Its practical implementation makes learning more engaging, stimulates active participation, and promotes a positive learning experience. It also prepares university students to perform at the level of professional innovation required by federal educational standards.

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