

# Scenario-Based Competence Assessment for Developing Behavioral Competences in Engineering Education: A Systematic Literature Review

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## Abstract

Competence assessment and development are constantly evolving, following methodological and technological advances. Scenario-based competency assessment as a tool to develop behavioral competencies has gained prominence in response of criticism of traditional assessment methods. Unlike conventional approaches, scenario-based assessment uses hypothetical situations based on real contexts, allowing participants to demonstrate their competencies in simulated environments that reflect everyday professional situations. The study aims to understand the state-of-the-art applicability of scenario-based behavioral competency assessment in engineering education. The researchers analyzed studies aligned with the central theme through a systematic review. The methodology followed the PRISMA guidelines, ensuring rigor in data screening, organization, and analysis. The results of this study show that, despite the intriguing and promising potential of scenario-based assessment, there is a significant gap between its practical application and its academic exploration in engineering. The analysis revealed a still limited mosaic of publications, suggesting that this approach, although recognized in other areas, such as medicine and education, remains largely unexplored in engineering education. This scenario highlights the need for further research and strategic planning to enable broader and more effective adoption of this methodology.

**Keywords:** Assessment. Competences. Scenarios. Systematic Review. Engineering Education.

## 1 Introduction

The competence assessment and development field are constantly evolving, reflecting changes in the methods and tools used (Wawak & Woźniak, 2020). Competency assessment emerged in response to the growing criticism of traditional tests, which were considered unrealistic assessment methods. As a result, there has been a decline in the confidence of tests as valid tools for measuring learning (McDowell, 1995). With the growing emphasis on competency-based learning and teaching, there has been an increasing demand for assessment methods to determine these skills effectively (Baartman et al., 2007).

Scenario planning is an assessment and learning approach used for over 50 years and has expanded over time. We can define scenarios as any activity that exemplifies specific situations or themes in the workplace (Carrol, 1999). Authors generally present these scenarios in the form of narratives, which can encompass a particular set of circumstances, a description of human behavior, an outline of events, a story of human endeavor, an incident in the workplace, or a human dilemma, on which the participant reflects to plan their actions.

This assessment method transcends the boundaries of different areas of knowledge, and its research has gained prominence in all countries. However, in the context of Engineering, this method is still relatively recent, especially when compared to areas such as Medicine and Education (Souza & Lima, 2020).

Given this scenario, the study aims to understand the state-of-the-art applicability of scenario-based behavioral competency assessment in engineering education. It seeks to answer the following research question: How can scenario-based competency assessment contribute to developing behavioral competencies, especially in engineering education? The researchers conducted a systematic literature review in the Scopus and Web of Science databases, following the protocol developed by Moher et al. (2009).

## 2 Theoretical Framework

The concept of "competence" continues to be widely discussed and interpreted differently in the organizational and occupational literature (Hijazeh, 2011; Sanghi, 2016). Although the concept was defined over three decades ago, its application in project management remains relevant for various purposes.

Several studies investigate aspects such as leadership development, cooperation, knowledge management, sponsor perceptions, and management in complex environments (Crawford, 2005; Kasvi, Vartiainen & Hailikari, 2003; Söderlund, Vaagaasar & Andersen, 2008; Turner & Müller, 2005; Geoghegan & Dulewicz, 2008; Müller & Turner, 2010; Gray et al., 2013; Suikki, Tromstedt & Haapasalo, 2006; Thomas & Mengel, 2008). These studies, often published in specialized journals, discuss the competencies that project managers must develop to achieve project objectives, emphasizing behavioral competencies.

Crawford (2005) proposed a tripartite classification of competencies: input, personal, and output. Input competencies refer to the knowledge and skills brought to the project, while output competencies are related to observable performance in the work environment. Personal competencies involve essential attributes that allow the individual to perform his/her role.

IPMA (2015) adopts a similar definition, describing competence as the practical application of knowledge, skills, and abilities to achieve desired results. Thus, a competent person has the necessary attributes to achieve the expected performance, as shown in Figure 1.

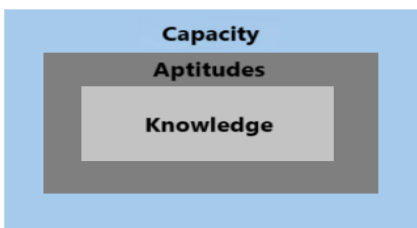


Figure 1. Representation of the Definition of the term Competence. Source: IPMA (2015)

According to IPMA (2015), the ten behavioral competencies of project management are: introspection and personal management, personal integrity and reliability, personal communication, relationships and commitment, leadership, teamwork, conflict and crisis management, engagement, negotiation, and results orientation.

The field of education has undergone substantial transformations, especially with the increasing adoption of competency-based approaches (Chappell et al., 2020; Griffith & Lim, 2014). The structure of assessment practices requires verifying whether the participant has the knowledge and what he or she can do with the knowledge acquired in real situations in the market environment (Mirza et al., 2023; Poth et al., 2020).

According to Marinho-Araújo and Rabelo (2015), assessment is a complex process that involves conceptions, beliefs, values, principles, theories, concepts, goals, desires, and trajectories. Developing the ability to identify, mobilize, manage, and use these sets of resources, together with knowledge, expertise, and other relevant characteristics, highlights an individual's competence.

In this context, one of the main challenges in the assessment process is to create activities and methods that encourage the practical application of skills. Ketele and Roegiers (2016) propose a classification of assessments into three distinct approaches. Instruments such as interviews and written tests are used when the assessment adopts the questionnaire approach. In the observation approach, rubrics and checklists are used. In document analysis, portfolios, reports, and self-assessment forms are used.

Scenario-based assessment is an approach in which hypothetical situations are created but grounded in authentic contexts to which individuals must respond. The tasks of this type of assessment and their items usually present a brief description of the situation, followed by questions or prompts designed to elicit behaviors or perceptions related to the construct under analysis. Scenario-based assessment thus offers a means of assessing individuals in meaningful and purposeful contexts, with tasks that reflect their experiences. This method is particularly effective in connecting informal but complex social activities, ensuring the collection of robust and reliable data on human behavior in real-world settings (Haynes et al., 2009).

Each assessment task is presented as a hypothetical situation, described orally to the participant, and based on everyday contexts. The strategy uses situations familiar to the respondents without requiring knowledge from formal educational experiences (Mutweleli et al. 2024).

### 3 Methodology

The researchers carried out a systematic literature review (SLR) using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, as proposed by Moher et al. (2009). The study selection process comprised four distinct phases — identification, screening, eligibility, and inclusion — as depicted in Figure 2. The PRISMA framework aimed to optimize the scope of the search and ensure methodological rigor in selecting relevant studies for the review.

The researchers collected data in December 2024 from the Scopus and Web of Science databases. The search strategy employed the following combination of terms: ("Skills Assessment\*" OR "Competences Assessment\*" OR "Competences Assessment Methods\*" OR "Assessment of Engineering Competences\*" OR "Competence Evaluation Model\*").

Table 1 presents the detailed inclusion and exclusion criteria for study selection.

Studies published in journals.

Relevant to the areas of interest: Education, Engineering and Business, Management and Accounting.

Classified as "Article" or "Review" document types.

Written in English.

The information was recorded in an electronic spreadsheet containing the author(s), year, location, objectives, methodology, and competence assessment criteria. Finally, the compiled data were subjected to a bibliometric analysis. This analysis aimed to identify patterns in scientific production and map the knowledge landscape, including authors and journals of greatest relevance to the topic investigated (Alfonso et al. 2021; Dutra et al., 2015).

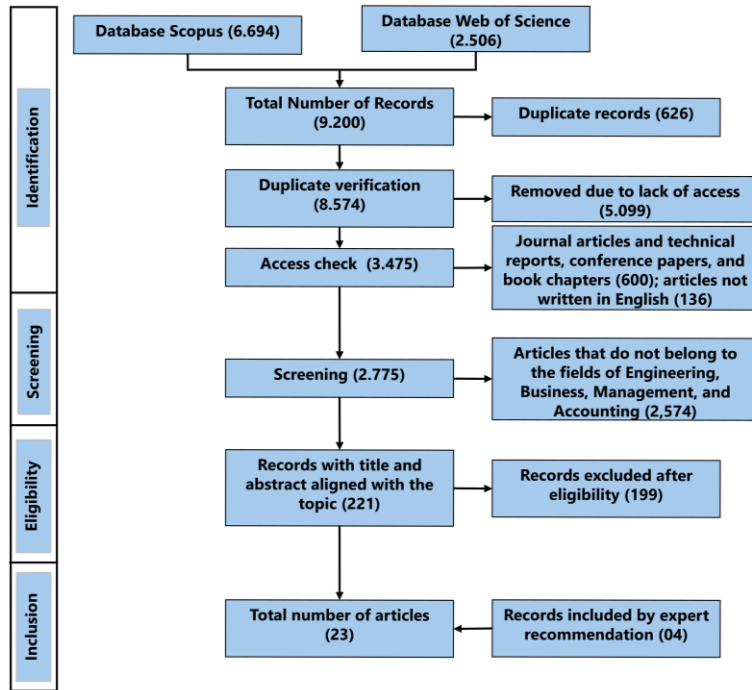


Figure 2. PRISMA method

## 4 Results and Discussion

The literature review selected 23 articles addressing different competence assessment methods. The data revealed a gap in the use of the scenario-based approach indicating that despite its potential, this methodology is still in its early stages in the field of engineering. Table 1 presents the main assessment methods identified in the studies.

Table 1. Competence assessment methods

Author(s)	Field of Application	Competence Assessment Method
Liu (2024)	Education	Questionnaire
González-Fernández et al., (2024)	Education	
Chouhan (2022)	Engineering and Business	
Hirschprung & Kordova., (2021)	Education	
Köuts-Klemm (2019)	Education	
Carr, Bowe & Ní Fhloinn (2013)	Engineering and Business	
Taylor et al., (2012)	Education	
Baartman et al., (2011)	Education	Scenarios
Davis et al., (2023)	Education and Engineering	
(2023)	Engineering and Business	
Souza et al., (2022a)	Education and Engineering	
Tinoco et al., (2023)	Engineering and Business	Self-assessment
Hero, Pitkäljärvi & Matinheikki-Kokko (2021)	Education	
Bohloulí et al., (2017)	Engineering and Business	
Achcaoucaou et al., (2014)	Education	Headings
Adorni et al., (2023)	Education	
Souza et al., (2022b)	Education and Engineering	
Succi & Wieandt., (2019)	Management and Accounting	Simulation/Games
Altomari, Altomari, & Iazzolino (2023)	Management and Accounting	
Politis et al., (2023)	Education	Observational
Gómez, Sabater-Mir & Sierra (2022)	Education	Peer review
Tang, Tsai & Huang (2020)	Education	Skill Hierarchy
Lin et al. (2018)	Education and Engineering	Based on Continuous Data

The analyzed articles highlight a range of skill assessment approaches, from traditional methods (such as questionnaires, interviews, and rubrics) to interactive ones, such as games and simulations.

The most commonly used method for assessing behavioral competencies in the literature is the questionnaire-based assessment, accounting for 35% of the studies. The Competency Assessment, through a **Questionnaire**, assesses professional competencies, including professional identity, planning, communication, methodology, innovation, collaboration, and meta-evaluation, essential for improving learning. The authors Liu (2024), González-Fernández et al. (2024), Chouhan (2022), Hirschprung and Kordova (2021), Köuts-Klemm (2019), Carr, Bowe and Ní Fhloinn., (2013), Taylor et al. (2012) and Baartman et al. (2011) actively use this form of assessment, applying it in various contexts such as universities and industries.

**Scenario-based assessment** represented 17% of the articles included in the research. The studies by Davis et al. (2023), Souza, Lima, and Mesquita., (2023), Tinoco et al. (2023), and Souza et al. (2022a) presented scenario-based assessment. This method exposes university students to unstructured problems that simulate situations aligned with professional practice. Participants can identify students' critical thinking and problem-solving skills by analyzing and answering questions related to the scenario presented. During university selection processes, educators and employers can apply the scenario-based assessment method to students and the industry.

**Self-assessment**, representing 13% of the articles, allows participants to reflect on their skills and knowledge. This method allows the assessment of seven individual skills related to innovation: personal characteristics, implementation and planning skills, project management, creative thinking, social skills, future orientation, and disciplinary knowledge (Hero & Lindfors, 2021). The research by Hero, Pitkäljärvi & Matinheikki-Kokko., (2021), Bohlouli et al. (2017), and Achcaoucaou et al. (2014) stands out in this method.

**Rubric-based assessment** accounts for 13% of the articles and allows the systematization of the evaluation process, establishing the relationship between skills and observable behaviors. This method presents an approach to model learning skills, assisting evaluators in analyzing student development (Adorni et al., (2023), Souza et al., (2022b), and Succi & Wieandt., (2019).

The other assessment methods represented 4% of the studies and consisted of simulations/games, observational, peer assessment, skills hierarchy, and assessment based on continuous data. In the study by Altomari, Altomari & Iazzolino (2023), **Simulation** was the assessment method that employed event sequence analysis techniques, comprising the organization and recording of the assessed person's actions and decisions. This method allowed the analysis of five behavioral competencies: problem-solving, teamwork, time management, decision-making, and communication. This method was developed at a university to identify and assess the essential competencies required by the job market.

The method characterized as **Observational Assessment** is based on the direct observation of individuals' behavior during social interactions, using previously defined criteria to analyze their conversational skills. This method was applied in an intervention context with young autistic adults on a virtual platform through training sessions held both in person and virtually, aiming to develop and improve these skills (Politis et al., 2023).

**Peer Assessment** allows the assessment of skills such as critical thinking, writing skills, self-assessment, and collaboration, highlighting its relevance in educational environments, especially in online courses (Gómez et al., 2022).

**Ability Hierarchy** is an innovative mathematics assessment system used in elementary schools. It analyzes learning difficulties by organizing skills into progressive levels, ensuring that participants master basic concepts before advancing to more complex topics, such as whole numbers, fractions, and area calculations (Tang et al., 2020).

The study by Lin et al. (2018) describes **Continuous Data-Based Assessment**, an approach applied to software engineering that measures technical and interpersonal skills through behavior analysis in authentic tasks. By integrating formative assessment practices with quantitative metrics, this method gathers and analyzes student activities within an agile development environment to evaluate their performance.

The systematic review findings highlight that most studies use the most traditional assessment method through the application of questionnaires, followed by the scenario method. However, there is a need for further studies on competency assessment, particularly about scenario modeling as a methodological tool. Although widely adopted in areas such as medicine and education, the application of competency assessment in engineering remains scarce, representing an opportunity for research and development. Studies such as those by Margalho (2022) and Souza & Lima (2020) highlight this gap by showing that most publications on scenarios in competency assessment focus on areas such as health and public management. The results indicate that the engineering field has not yet adopted this methodology significantly in its assessment practices.

In this sense, the results corroborate the scarcity of research on the topic and indicate the potential of scenarios as a promising methodological approach for assessing competencies. This approach enables a more dynamic, interactive, and contextualized environment, favoring the measurement of participants' competencies (Souza, Lima, & Mesquita, 2023).

In the academic context, higher education institutions have intensified their efforts to reach the business sector. This movement is a result of the growing market demand that has stimulated the transformation of classrooms, ensuring that students develop not only solid theoretical knowledge in their areas of study but also behavioral skills that are essential for good professional performance and aligned with contemporary demands (Castaño Urueña et al., 2024; Ogunrinde, 2022). The literature shows a series of limitations related to the traditional teaching model, contributing to students' inability to solve problems, work in teams, and communicate (Hansen & Luxhøj, 1995; Souza, Lima & Mesquita, 2019).

Thus, the scenario-based competency assessment method can potentially assess behavioral competencies more realistically and aligned with the professional demands of the job market. Scenario-based assessment is believed to allow the participants to mobilize their competencies, express their reasoning more openly, and use creativity in a visual, dynamic, practical, and interactive process (Tinoco et al., 2023).

## 5 Conclusion

This study examined the application of scenario-based competence assessment in engineering education, highlighting the lack of research exploring this approach in this field. The systematic review showed that, although there are several assessment methods in the literature, the use of scenarios to measure competencies is still little explored in engineering, in contrast to its consolidation in areas such as medicine.

The results indicate that scenario-based assessment can be a promising alternative to traditional methods. It enables the assessment of technical and behavioral skills and fosters critical thinking and decision-making in contexts similar to professional reality. This approach stimulates problem-solving, teamwork, and adaptation to complex situations in engineering education, promoting more dynamic and contextualized learning.

Thus, scenario-based assessment contributes to developing behavioral skills by exposing students to challenges that simulate actual professional conditions. However, empirical studies are still needed to validate its effectiveness in engineering education.

In light of this, it is recommended that structured models be developed and comparative studies conducted alongside conventional assessment methods to evaluate their impact on student education. By highlighting

the potential of this methodology, this study reinforces the importance of deepening both the theoretical foundation and empirical investigations, encouraging new research that expands its application in engineering.

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