2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering
Education for 130 Years
Paper ID #37155

Proposition of a Method to Monitor Higher Education Students' Competence Development through Assessment Rubrics

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METHOD TO MONITOR HIGHER EDUCATION STUDENTS' COMPETENCY DEVELOPMENT THROUGH ASSESSMENT RUBRICS

Abstract

The competency-based education model has been one of the paths taken by higher education institutions concerned with offering programs relevant to the market and societal needs. However, adapting teaching to a competency-based education model can bring many challenges, such as assessing and monitoring competencies. Indeed, few studies address how to structure and implement a comprehensive competency-based education model and systematically assess and monitor competence development. This article proposes a method for evaluating the development of curricular competencies of Industrial Engineering undergraduate students at the Federal University of Rio Grande do Sul in Southern Brazil. The method uses assessment rubrics as a tool for faculty to assess student competence development throughout the entire program. More specifically, we propose rubrics to assess competencies at three stages: initial (first semesters of the program), intermediate (approximately halfway through the program), and final (final semesters) in order to track their development throughout the program. The developed method follows four steps: i) selection of the courses for the competence assessment; ii) development of the assessment rubrics; iii) definition of methods and tools for applying rubrics; and iv) definition of how competence assessment rubrics would be organized and communicated. The assessment rubric developed is a table-like structure composed of four parts. The first has the three elements of competencies (knowledge, skills and attitudes). The second has the expected learning outcome for each one of the three elements. The third has the descriptors for each of the four performance levels (beginner, under development, satisfactory, and advanced) per learning outcome. The fourth and last one shows the courses where each learning outcome will be assessed. The method was tested in an Industrial Engineering undergraduate program at the Federal University of Rio Grande do Sul in Brazil. Regarding the assessment results, the method proposes that faculty members must provide feedback to students and use these results to promote improvement in the development of competencies throughout the course. This method allows the undergraduate program to monitor how students developed each competence at different performance levels throughout the courses. Based on the results, we expect to encourage the method's use to monitor the development of university students' competencies.

Keywords: Competence Assessment; Learning outcomes; Rubrics; Engineering Education.

1. Introduction

The competency-based education model, widely supported in the literature [1]-[3], has been one of the paths taken by higher education institutions concerned with offering undergraduate programs aligned to the market and societal needs. The concept of competency aims to link the market and academia, stimulating debates about what future engineers are expected to know, do, and behave professionally. This concept is also essential in studies on the profile of the modern engineer, and higher education institutions have been under pressure to develop competencies in their students to align with society and the labor market needs [4]-[7].

Yet, to achieve that, a curricular transformation is necessary to adapt teaching to a competency-based training model. According to a report published by the United Nations Educational, Scientific, and Cultural Organization [8], and a study by Erasmus and Knowledge Alliance, a new balance in the curriculum is required to develop the technical and behavioral competencies required for engineers to work in the labor market and improve their employability [4], [9].

An important challenge of this training model is monitoring and evaluating students' competence development throughout the program, which requires the development of robust assessment methods [4], [9], [10]. One of the most commonly used approaches for assessing the competencies of undergraduate students is unfolding these competencies in learning outcomes, which are smaller operative units of the competencies. These learning outcomes explicitly define what a student is expected to know, understand, demonstrate, or accomplish by the end of a learning period [11] - [14]. According to Williams [15], defining the learning outcomes for an engineering undergraduate program is the critical first step in revising the curriculum, developing courses, and creating an assessment plan.

Learning outcomes can be used by faculty to assess students' learning progress throughout the program and should be defined for each competence. Evaluation rubrics have been adopted to measure the various levels of competence development. Rubrics are valuable tools in student assessment and help indicate students' learning level for the learning outcomes [16], [17].

The use of rubrics assists educators in evaluating students' competencies by defining different levels of mastery for each competence. It also enables faculty to identify student knowledge and skills gaps [18]. Rubrics are also popular because they bring objectivity to student assessment by acting as a guide with clearly defined criteria [19]. As a result, the rubrics must be presented by professors to students to understand what is expected from them as a learning outcomes at the end of the course and how they will be evaluated. Then, the rubrics must be used by professors as a guide in the teaching and learning process [17].

Rubrics can also be used as a feedback tool, not only for students but also for the program coordinators. The use of learning outcomes and rubrics allows the identification and communication of students' competence development need as well as potential curriculum gaps. Based on the analysis of this information, improvements in line with competency-based education can be developed [7], [20], [21]. However, few studies demonstrate how to use these methods to systematically assess and monitor competencies, with a focus on the dissemination of these results and their ability to identify gaps and opportunities for program improvement.

2. Description of the study context

Following international teaching and learning trends, the Industrial Engineering program at the Federal University of Rio Grande do Sul (UFRGS) has been remodilling its curriculum since 2019 to implement the new National Curriculum Guidelines (DCNs) for engineering in Brazil. These guidelines promote the development of teaching based on competencies [22] - [24]. According to the Brazilian Association of Industrial Engineering [25], the new curriculum organizes and integrates the various teaching activities into seven blocks: (i) Production; (ii) Optimization; (iii) Quality; (iv) Human Factors; (v) Project/Product; (vi) Production Economics; and (vii) Technology [24].

UFRGS’s Industrial Engineering undergraduate program participates in the Modernization of Undergraduate Education program (PMG) [26] as a pilot project to address the challenge of implementing a competency-based curriculum. This pilot project to promote engineering program modernization in Brazil is sponsored by (i) the U.S. Embassy in Brazil, (ii) the Brazilian development agency for Coordination for the Improvement of Higher Education Personnel (CAPES), and (iii) the Fulbright Commission in Brazil. The PMG supports changes in engineering programs by assisting in redesigning the curriculum based on competencies, including innovative pedagogical practices and developing new methods of student assessment [24], [26]. This article proposes a method for evaluating and monitoring the development of students' competencies throughout the undergraduate Industrial Engineering program based on the results and experiences generated by PMG’s Evaluation Working Group (EWG) activities during 2021 and 2022. The EWG comprises three program professors, one of them is the Program implementation Coordinator at UFRGS's School of Engineering, and two doctoral students from the same School of Engineering.

3. Methodology

The adopted methodology aims to generate knowledge for practical application to solve specific problems [27]. In this study, the problem is developing a method of evaluating and monitoring competencies applied to the Industrial Engineering program. The research method is qualitative, with data collected without numerical measurement to uncover or improve research questions [28]. According to Gil’s definitions, the classification based on objectives is exploratory, as few studies assess the research theme [27]. This study is classified as a case study because it explores one or a few objects and describes the context in which a specific investigation is being carried [27]. Also, the bibliographical research is based on previously prepared material, primarily books and scientific articles [27].

The methodological procedures for achieving the goals are divided into three stages: i) Definition of the research problem; ii) Theoretical-practical foundation of the method; and iii) Structure of the proposed method. A meeting was held in the first stage with the coordination of the PMG of Industrial Engineering at UFRGS and the Program's Undergraduate Commission (COMGRAD) coordinators. The interview aimed to understand the programs' competence assessment assumptions and objectives and identify which competencies would be evaluated.

The main challenges of implementing the new competency-based curriculum were identified during the interview. The new curriculum, developed as part of a curriculum redesign process to modernize the program, was implemented at the Department of Industrial and Transport Engineering (DEPROT/UFRGS) in the first semester of 2021, and the assessment of students' development of curriculum competencies was the most critical demand. The new curriculum was designed around 15 competencies, according to Table 1.

In the second stage, gathering information from the literature was critical to establish the principles and theoretical foundations for developing a method for evaluating and monitoring education based on competencies. The keywords "Assessment by Competences", "Analytical Rubrics," and "Undergraduate Engineering Education" were used in the literature search. Academic articles in English from the previous two decades were prioritized. Furthermore, benchmarking analyses were organized based on PMG partnerships with North American institutions (the University of Central Florida, the University of Florida, the University of

Pittsburgh, and the University of Illinois at Urbana Champaign) [24]. Additionally, the EWG participated in workshops with PMG experts and training for two years. Also, the Mecek Laboratory's team from Argentina provided workshops founded on competency-based education.

Table 1. Competencies of the new curriculum of Industrial Engineering

Technical	1. Design, implement, and optimize processes, products and systems
	2. Manage complex production systems with a systemic view
	3. Collect, analyze and interpret data to improve operations
	4. Predict the evolution of production systems, innovate and undertake
	5. Integrate new concepts, methods, and technologies
	6. Offer value by integrating products and services
	7. Acting with social responsibility
	8. Acting with environmental responsibility
	9. Acting with economic and financial guidance
	10. Acting with market orientation
	11. Identify and solve society's problems
Cross-disciplinary	12. Acting ethically, respecting everyone involved
	13. Lead, work in a multidisciplinary team and manage conflicts
	14. Communicate in oral, written, and graphic form
	15. Learn and update yourself continuously

The method was structured in the third stage to assess and monitor the development of curriculum compentecies by the students of the Industrial Engineering Program at UFRGS via brainstorming sessions led by the EWG. Based on information gathered from the second stage, the method's structure was evaluated for its feasibility of implementation and alignment with the challenge of education by competencies in engineering courses, internally by the Program's Undergraduate Commission (COMGRAD) and externally by the University of Central Florida specialists. The proposed method is presented in section 4, based on the lessons learned during its development and implementation in the program.

4. Proposed competency assessment and monitoring method

One of the underlying principles of the proposed method was the use of rubrics as a competency assessment approach. That included defining the desired learning outcomes and the performance levels for each competency of the undergraduate's profile (e.g., [2], [6], [16], [17], [29]). Table 2 summarizes the assumptions used in the development of the proposed method, which is based on [17], [30] and [31]. These assumptions were confirmed through benchmarking activities with North American partner universities and interactions with PMG specialists [24].

Table 2. Synthesis of the proposed method's premises

Premise 1	The method is intended to track the progression of students' competency development throughout the program
Premise 2	Each competency is evaluated three times during the program, at the beginning, intermediate, and final semesters, so that competencies can be monitored and improved
Premise 3	Competency evaluation is carried out in a number of courses from the program
Premise 4	The result of the competency assessment may differ from the result of the subject assessment
Premise 5	The evaluation is formative

The competency assessment method was created in four stages: a) Selection of competency assessment subjects; b) Development of rubrics; c) Definition of methods and tools for applying the rubrics; and d) Structured communication of competency assessment results.

a) Selection of courses for competency assessment

The courses to evaluate and monitor competencies throughout the program were chosen based on their contribution to the competencies in the graduates' profile [3]. Based on the results of Demore et al. [23] and subsequent curricular updating of the Undergraduate Program's Pedagogical Project in 2021 [24] the courses with the biggest contribution to development of student’s competencies were selected [23]. This definition followed the levels of Bloom's taxonomy (1) Remember; (2) Understand; (3) Apply; (4) Analyze; (5) Evaluate; and (6) Create [32]. The EWG chose a set of courses to assess and monitor the development of competencies throughout the students' education trajectory based on this contribution of each course to the development of competencies in the undergraduate's profile.

Therefore, each competency is evaluated in three stages throughout the course: initial (first semesters of the program), intermediate (approximately halfway through the program), and final (final semesters) to track their development. The competency measurement structure chosen is consistent with the approach proposed by [17]. In this manner, 39 professionalizing courses were chosen (Industrial Engineering-specific courses), the majority of which were mandatory, for evaluating and monitoring students' competencies throughout the three stages.

b) Developing evaluation rubrics

The first step in developing rubrics is to divide competencies into learning outcomes, which are smaller operational units related to the three types of knowledge (to know, to do, and to be) (e.g., [29], [33] - [35]). Defining learning outcomes and developing rubrics was based on the Agencia Nacional de Evaluación y de la Calidad y Acreditación's support guide for writing and evaluating learning outcomes [36]. The construction of the evaluation rubrics for the Industrial Engineering Program involved the professors of the selected courses based on the performance of 15 workshops conducted by the EWG during 2021, one workshop for each competency.

During the workshops, the process of developing the rubrics, composed of learning outcomes and performance level descriptors, was explained to the professors using expository material composed of three videos prepared by the EWG. Then, faculty members would describe how their courses helped develop the given competency being discussed, and what learning outcomes were expected for a student in the advanced level (that is, for a student who fully developed the given competency in its advanced level). Afterwards, professors worked backwards to establish the other two levels of competency development (under development and satisfactory). The “beginner” performance level was defined to be a statement that defined a student that could not manage to achieve even the “Under development” performance level. As shown in Figure 1, the structure used to create learning outcomes presented in this material is composed of: verb + object of knowledge + purpose + condition [35] - [36].

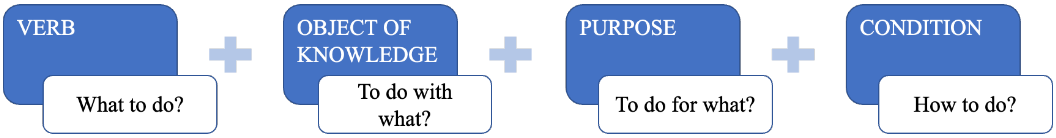

Figure 1. Structure of the Learning Outcome adopted in the proposed method

Each competency was divided into learning outcomes for the three knowledge types (to know, to do, and to be), related to the competencies’ elements (knowledge, skills and attitudes) and were evaluated on four levels of performance (beginner, in development, satisfactory, and advanced) [17], [30], [31]. The 'Beginner' level represents the lack of competency development, whereas the 'Advanced' level represents the described learning outcome itself, indicating that the student developed the competency at a fundamental level. The intermediate levels, 'Under Development' and 'Satisfactory,' differ based on the degree of complexity of the verb used in the rubric's description.

Table 3 provides an example of a rubric for competency 14, which is called “Communicate orally, written and graphically”. The initial level of competency 14 is evaluated in the third semester through the “Quality Engineering” course. The intermediate level is evaluated in the seventh semester in the “Service Management” course, while the final level is evaluated in the ninth semester through the “Capstone Project” course. For each type of knowledge, we defined a learning outcome and developed performance levels that students must meet based on the course they are taking.

The verbs used to define learning outcomes and performance levels were chosen using taxonomies from the *cognitive domain* or an adaptation of Bloom's taxonomy [32], the *psychomotor domain*, which is related to competencies [35], and the *affective domain*, which is related to attitudes [37]. The proposed evaluation method also defines the percentages of students expected to achieve in each of the evaluated performance levels. The EWG defined these goals, which the Program's COMGRAD and professors validated during the workshops, based on benchmarking actions with partner universities.

Table 3. Example of an assessment rubric for competency 14

Competency: 14. Communicate orally, written and graphically		**Performance levels**				**Courses for assessment and student's goals (%) per stage**		
Type of knowledge	**Learning Outcomes**	**Begginer**	**Under development**	**Satisfactory**	**Advanced**	**Quality Engineering**	**Service Management**	**Capstone**
Knowledges	Create oral, written and graphic content with originality to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Fails to organize oral, written and graphic content to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Organize oral, written and graphic content to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Analyze oral, written and graphic content to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Create oral, written and graphic content with originality to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	50%	60%	70%
Skills	Create presentations and reports with originality to meet the demands related to Ind. Engineering, with clarity, logical organization, and grammatical accuracy.	Fails to organize presentations and reports to meet the demands related to Eng Produção with clarity, logical organization, and grammatical accuracy.	Organize presentations and reports to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Improve presentations and reports to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Create presentations and reports with originality to meet the demands related to Ind. Engineering, with clarity, logical organization, and grammatical accuracy.	50%	60%	70%
Attitude	Demonstrate fluency in oral, written, and graphic communication of content, with clarity, logical organization, and grammatical accuracy.	Fails to demonstrate fluency in oral, written, and graphic communication of content with clarity, logical organization, and grammatical correctness.	Demonstrate some oral, written and graphic fluency in communicating content with perspicuity, logical organization and grammatical accuracy.	Demonstrate moderate oral, written and graphic fluency in communicating content with perspicuity, logical organization and grammatical accuracy.	Demonstrate fluency in oral, written, and graphic communication of content, with clarity, logical organization, and grammatical accuracy.	50%	60%	70%

c) Definition of assessment tools for the use of rubrics

Students are subjected to a formative assessment process, which focuses on assessing how the students' learning process is going, at three different times throughout the program defined as Initial, Intermediate, and Final stages, based on the proposed method. According to data collected in the literature, formative assessment becomes crucial to identify the student's evolution throughout the program [21], [38]. The use of evaluation tools found in the literature, particularly the study by Martinez et al. [20], is suggested to assess curriculum competencies and standardize the use of rubrics by professors. Presentations, assessment activities, and self-assessments are suggested as technical competencies tools. In addition to the tools proposed for technical competencies, assessments by classmates (peer review) guided by structured rubrics and observation of students during classes are suggested for behavioral or transversal competencies. As a result, the teacher will have multiple sources of evidence to analyze the student's competency and determine which is of the four levels of performance the student has. Various tools for formative and summative assessment of the technical and transversal competencies of the engineering profile were indicated to the professors during the Industrial Engineering Undergraduate Program workshops. This procedure aimed to provide the teaching staff with a toolbox for selection and use in the evaluation processes.

d) Organizing the communication of the competency assessment results

The final stage of the proposed method is the demonstration of competency assessment, based on the information flow of the results obtained through the use of rubrics by the professors and the format of presentation of this information to the students, program coordinators, and program managers. The definition was based on a search of the literature on competency analysis and the expected objectives with the evaluation of curricular competencies and an interview with the COMGRAD coordination. The assessment results based on competencies will be shared with (i) students, (ii) Program coordination, and (iii) Program managers. The goal is for each party to use the results to identify their strengths and areas for improvement [7], [20], [21].

After evaluating each student's performance level based on the competency rubric, professors must complete a standard spreadsheet containing the percentages of students in each performance level for each learning outcome. These results should be sent to COMGRAD, which will compile data for all curriculum competencies every six months. COMGRAD compiles these results, using bar graphs or a Pareto diagram to facilitate competency analysis, and forwards them to the program managers, which has as one of its goals to contribute to the consolidation of the professional profile of the program. Figure 2 depicts an hypothetical example of compiling these results for one of the competencies. This figure illustrates the students' evaluation organized by evaluation stage (initial, intermediate, or final) based on the three knowledge types (to know, to do, and to be), related to the competencies' elements (knowledge, skills, and attitudes). A similar figure will be created for each competence to evaluate the percentage of students reaching the evaluation stage.

The students' performance in each competency is analyzed in various stages, and knowledge can be monitored. Based on a comparison of the established goals and the percentages of students in each of the four defined performance levels, it is possible to determine if students are developing competencies with lower-than-expected performance (beginner, in development, satisfactory, advanced). The program managers must analyze the results of the competency assessment every six months to monitor the development of competencies throughout the program. That enables actions to be taken to reinforce the development of competencies with subpar performance in the end.

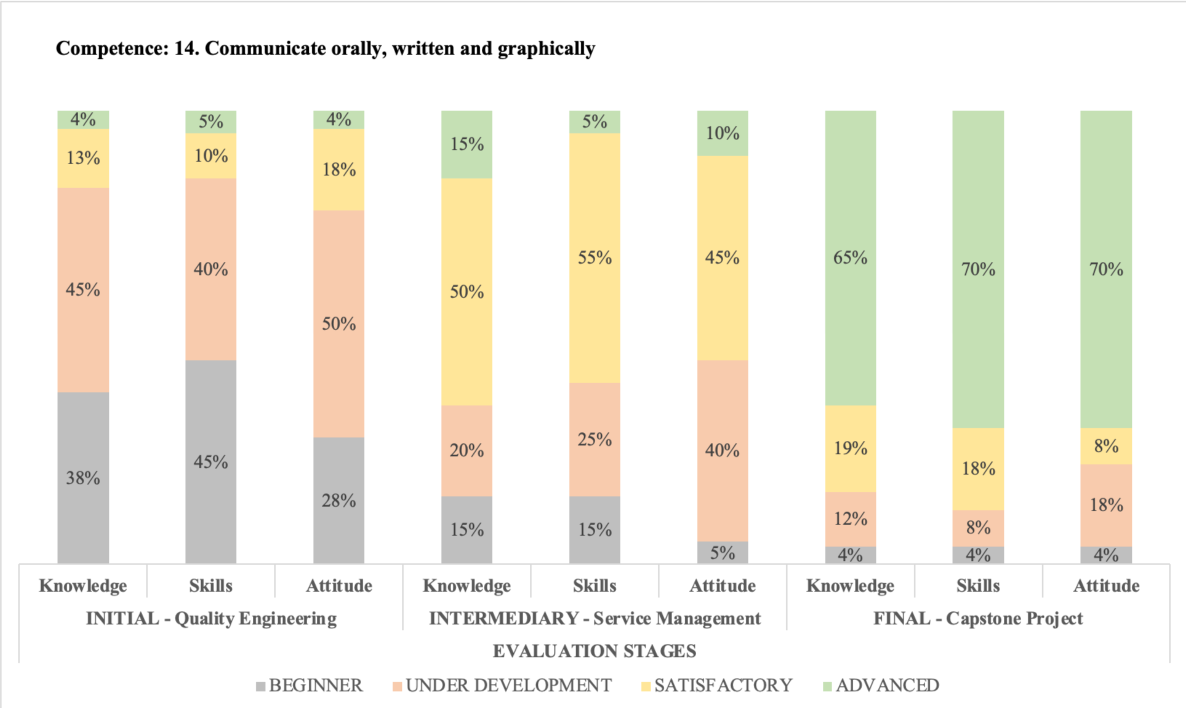

Figure 2. Program student performance in a competency across three assessment stages

The method used in the Industrial Engineering Undergraduate Program was tested until the end of 2022. Following this period, the outcomes and the method suitability will be evaluated based on identified improvement needs such as reviewing learning outcomes, redefinition of established goals, or other points that require adjustment. In 2024, the method will be used to diagnose curriculum competencies' development effectively. Feedback to students should begin after the method testing period and can take various forms. As a short-term strategy, feedback on competency development can be provided to students via the institutional Moodle platform in disciplines responsible for competency assessment. According to research, real-time feedback on progress will assist students in identifying the evolution of their performance and, as a result, actively improve the development of their competencies throughout the Program [21].

As an illustration, Service Management course was set to measure the proportion of students who developed competency 14 at the intermediate level. According to the percentages presented in Table 4, less than a quarter of the class achieved a satisfactory or advanced level in all competency elements. However, when the final evaluation stage was analyzed, over 65% of the students in the Service Management course achieved advanced levels in every competency element. Students who were at an underdeveloped level could enhance their competencies by taking additional courses until the end of the program. The students will receive a report with their performance in each analyzed competency, in each course, with the course grades for approval, via the institutional Moodle platform.

Tabela 4. Example of a competency assessment in the three stages of evaluation within a course

Course: Service Management
Minimum grade required: 6,0
Maximum grade: 10
Expected level of competence: satisfactory

Student identification	Academic Records						Performance level in learning outcomes related to the competency: 14. Communicate orally, written and graphically		
							Knowledge	Skills	Attitudes
	Assignments (10%)	Teamwork oral presentation (10%)	Teamwork report (30%)	Text 1 (25%)	Text 2 (25%)	Final grade	Analyze oral, written and graphic content to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Improve presentations and reports to meet the demands related to Ind. Engineering with perspicuity, logical organization and grammatical accuracy.	Demonstrate moderate oral, written and graphic fluency in communicating content with perspicuity, logical organization and grammatical accuracy.
303359	9,7	9,0	8,8	8	9,0	**8,8**	Satisfactory	Satisfactory	Satisfactory
303226	9,7	9,0	9,0	8	6,9	**8,3**	Satisfactory	Advanced	Satisfactory
282257	8,4	8,5	8,3	8,8	4,4	**7,5**	Satisfactory	Satisfactory	Satisfactory
309386	7,5	8,8	8,8	9,3	6,9	**8,3**	Satisfactory	Satisfactory	Satisfactory
193526	8,1	8,8	5,0	6,7	5,3	**6,2**	Satisfactory	Under development	Under development
278964	8,6	9,0	8,9	8,4	5,1	**7,8**	Satisfactory	Satisfactory	Satisfactory
301510	8,2	9,0	5,0	8,1	6,4	**6,9**	Satisfactory	Under development	Under development
279876	7,7	8,7	8,9	9,3	7,6	**8,5**	Satisfactory	Satisfactory	Satisfactory
266178	9,5	8,5	8,5	8,3	7,2	**8,2**	Satisfactory	Satisfactory	Satisfactory
243860	9,5	8,8	8,8	8,2	6,9	**8,2**	Satisfactory	Satisfactory	Satisfactory
282258	9,6	8,8	9,0	8,2	6,4	**8,2**	Satisfactory	Advanced	Satisfactory

Furthermore, according to Zlatkin et al. [39] recommendation, the student's overall performance in each competency of the undergraduate profile will be released on the institutional Student Portal every six months. This chart will illustrate data from the courses in which each competency was evaluated. Figure 3 depicts a hypothetical example of the graph. It is possible to identify the student's strengths and weaknesses concerning curricular competencies and create personal strategies that allow the students to develop them based on results received by the student throughout the entire undergraduate program.

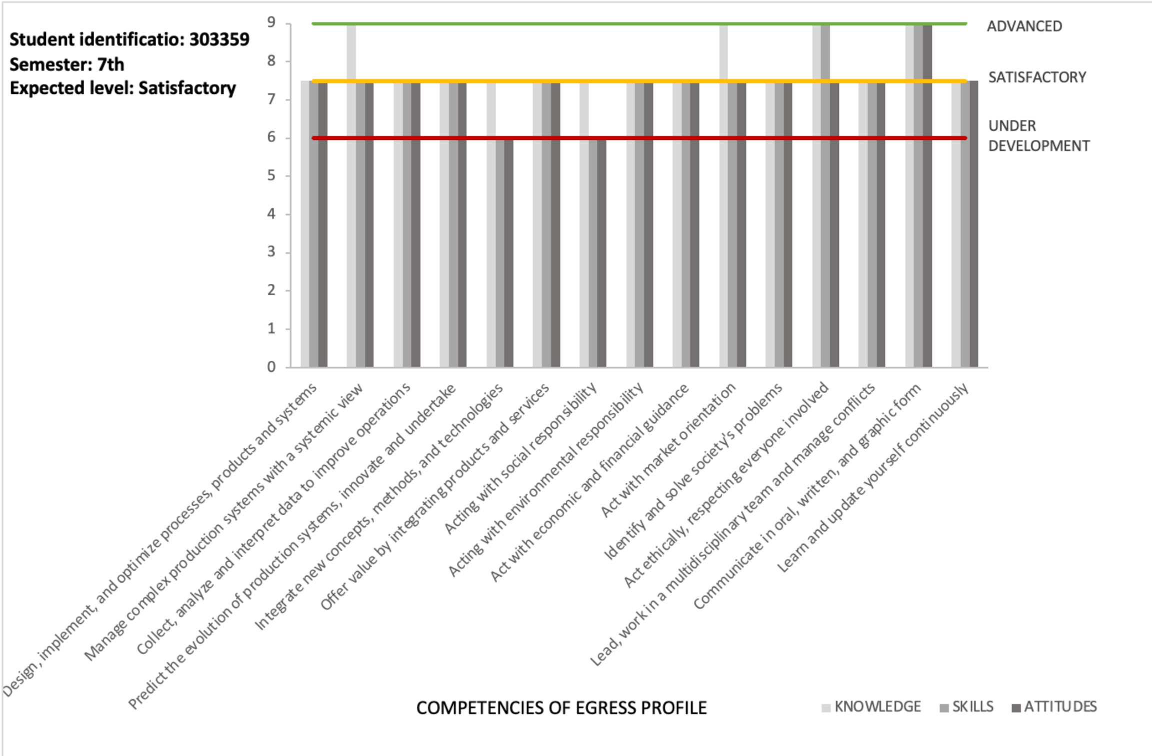

Figure 3. Example of demonstrating student performance in Program competency assessment

Following the PMG objectives, this method assists students in raising awareness and taking the lead in the competency development process [24]. Based on curriculum competencies development, the method will assess whether the new curriculum improves the desired Industrial Engineer profile after a test period. Also, the program managers will be able to determine if the established objectives are being achieved and how to proceed if they are not meeting expectations, establish action plans for continuous improvement of the method, and curriculum adaptation. The statement of the evaluation results allows monitoring of which knowledge and Program stage the students are not reaching the goals. This information should be used as a basis for new teaching strategies and the development of students' competencies.

5. Lessons learned and conclusion

This article aims to present a method for evaluating and monitoring the development of competencies of the undergraduate students at the Federal University of Rio Grande do Sul's Program in Industrial Engineering. The goal was addressed through literature research, benchmarking actions, training of the EWG, and PMG-promoted experiences. A real-world case study inspired the proposed method in the UFRGS Industrial Engineering Program. COMGRAD's coordination evaluated its feasibility of implementation in the program, confirming the ease of implementation by professors with the institution's traditional evaluation system. Furthermore, experts from PMG and the University of Central Florida who participated in the study confirmed its alignment to favor the implementation of a competency-based education model, considering the specificities of the Brazilian university context.

The proposed method considers the evaluation of the competencies in three stages (initial, intermediate, and final) throughout the program. First, specific professional courses that contribute to four different levels of performance in the development of competencies (beginner, in development, satisfactory, and advanced) were selected. Evaluation rubrics were developed in collaboration with course professors to assess competency development based on the definition of learning outcomes and respective descriptors for four performance levels. In addition, this method includes the generation of feedback to students on the development of their competencies, as well as the analysis and monitoring of the results generated by the undergraduate program coordinators, to improve the education model based on competencies continuously.

One of the primary lessons learned from developing and testing the competency assessment model in the Production Engineering course at UFRGS is the significance of training and engaging professors in implementing curricular changes that prioritize competency formation, particularly in adopting rubrics as a student evaluation method. Developing rubrics for each competence, while considering the definition of learning outcomes in the three areas of competence knowledge (knowledge, skills, and attitudes), was a challenge for most professors whose courses were primarily focused on evaluating content or knowledge through summative assessment techniques. In such cases, it was crucial to involve the coordination of the engineering program and the PMG program to engage professors and assist in developing these rubrics through workshops.

The training provided by the MECEK laboratory on competence-based education in engineering courses and the experiences facilitated by the PMG program, in partnership with experts from North American universities, were crucial in understanding tools and methods for competency evaluation, their application in the Brazilian context, and organizing workshops conducted by the EWG to create rubrics. During the testing phase of the method in the engineering program, the preliminary results demonstrate satisfactory outcomes due to increased visibility for students, teachers, and course coordination on competency development during the evaluation stages. However, there is still potential for improvement in the rubrics developed, as well as the adjustment of goals and tools employed. Despite this, faculty engagement in the use of rubrics to assess competency development is still not widespread.

The competency assessment in the university environment is still new in the literature, and few studies address a model that includes assessing and monitoring students' competency development. The current study provides a theoretical foundation and insights into developing and implementing methods for assessing and monitoring the students' competency development. The proposed method has been tested since the second semester of 2022, and it can be improved and developed based on the first uses to better adapt to the program. In the future, the program coordinators and managers should define which analyses will be performed based on the results of the assessments and how these analyses will be translated into action plans to improve the development of students' curricular competency. It is also recommended to implement a student communication tool for them to access the rubrics, their assessment results, and their self-assessment.

Future research could also explore how the method and competencies outlined in this study relate to ABET accreditation, as the generic competencies of graduates are aligned with those advocated by ABET. ABET accreditation is used by many universities worldwide as a competency model to ensure students acquire the skills required for professional success. Furthermore, additional research could investigate whether the proposed method and feedback given to students enable competence improvement in the Industrial Engineering Undergraduate Program.

Acknowledgment

The authors would like to thank CAPES, the Fulbright Commission, and the American Embassy for their assistance in carrying out the PMG research, the North American universities' partnership as benchmarking, and the Laboratorio Mecek team for the training provided.

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