A Diagnosis on the Teaching of Software Project Management in a Sample of Computing Courses at Brazilian Universities

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***Abstract*—This study analyzes the curricula of a sample of computing courses at Brazilian universities focused on software project management. These are the compared with the guidelines of the ACM/IEEE and PMBOK 7th edition. The selection of universities was based on the 2023 Folha University Ranking, resulting in curricula, pedagogical plans, and syllabuses being collected and analyzed from 22 institutions. The analysis revealed that the curriculum was organized into three categories, each of which was complemented by practical activities. Most universities offer these courses as compulsory modules, with an average workload of 64 h. The main courses include Software Engineering, Project Management, and Project Administration. A comparison of the ACM/IEEE guidelines and the PMBOK 7th edition principles revealed strong convergence, emphasizing the importance of structured processes, diverse management methodologies, and the consideration of human and ethical factors. These results suggest that Brazilian educational institutions adhere to international best practices. This study reflects the significant efforts of Brazilian institutions to prepare students comprehensively for the challenges of working in software project management.**

***Keywords*—software project management, education, curriculum analysis, Brazilian universities, diagnosis**

I. Introduction

The crucial role of project managers in organizations has made the teaching and learning of project management an increasingly interesting topic in higher education research [1]. However, Software Project Management (SPM) education faces several challenges. Researchers have highlighted that SPM education does not currently meet needs of the industry [2].

Project management is often approached theoretically. Nevertheless, there are several issues that researchers and instructors must address to improve SPM education [3]. According to Radermacher and Walia [3], and Ramazani and Jergeas [4], educational and training approaches for SPM professionals fail to meet the needs of modern organizations because current education does not adequately prepare managers to deal with real-world complexities.

A crucial aspect is that education must be more closely linked to practice. When comparing software engineering education with industry expectations, it is evident that Computing programme graduates have knowledge deficiencies in several areas [3].

In Moreno *et al.* [5], the relationships between recommended Computing competencies and relevant skills for software professionals were identified by comparing several curricula and job profiles. The results showed that, despite the existence of curricular guidelines, not all the basic knowledge required for work in the industry was covered. This means that students still graduate with knowledge gaps even when these guidelines are implemented in specific colleges or universities.

In light of the above, this study aims to examine the landscape of SPM teaching in a sample of Computing courses at higher education institutions in Brazil. To this end, an analysis was carried out on the selected course subjects in order to identify the content taught, how it is divided, the course loads and other points discussed in Section IV.

Using the 2023 Folha University Ranking (RUF) [6], 22 universities were selected, most of which offered SPM as a compulsory subject, with an average workload of 64 hours. This workload integrates fundamental concepts, management methodologies (including agile and traditional frameworks), and human aspects such as diversity and stakeholder management. The theoretical content is reinforced by practical activities, such as case studies and simulations.

A strong convergence was evident in the comparative analysis between Brazilian curricula, international guidelines, and the Project Management Body of Knowledge (PMBOK) 7th edition, indicating alignment on key topics such as the project life cycle, process management and agile methodologies. However, greater standardization and a focus on adaptive practices and leadership according to project needs are recommended.

In addition to this introduction, this article is organized as follows: Section II presents the theoretical basis for understanding this research; Section III describes the methodology used; Section IV presents the results obtained from analyzing the Pedagogical Projects of the Courses (PPCs); Section V discusses these results; Section VI presents threats to the validity of this study; and, finally, Section VII presents the conclusions of this work.

II. Background

A. Education in Software Project Management

One of the main challenges for a professor is getting students interested in and motivated by the content. When the topic is naturally interesting, engaging students seems easier than with less engaging modules. In both cases, however, professors must find the best ways to capture students' attention, facilitate learning, and prepare them to apply this knowledge in future [7].

Software project management is recognized by the Association for Computing Machinery (ACM) the Institute of Electrical and Electronics Engineers (IEEE) as a relevant subject for the training of Computing professionals [8].

Studies by Peters and Moreno [9] and Moreno *et al.* [10] have already demonstrated that the PMBOK Guide [11] can form the basis of a robust SPM course, equipping current students and future project managers with the necessary skills.

According to Kuhrmann and Münch [12], SPM is difficult to teach and is therefore often approached in an abstract way, providing basic knowledge of planning, estimation, and control activities. Furthermore, learning SPM at university is more challenging due to a lack of practical experience and the inherent complexity of these projects [13]. Although traditional teaching methods such as textbooks and lectures can provide a solid foundation, they often fail to capture the complexities and unpredictability encountered in real-world situations.

Therefore, it is necessary to create project management courses or subjects that focus on new methodologies, encouraging active student participation and preparing students for day-to-day life of a software project manager [14].

B. SBC and ACM/IEEE Curricula for Computing

In 2017, the Brazilian Computing Society (SBC) prepared Computer Training References for the courses listed in the Brazilian Curricular Guidelines of the Ministry of Education (MEC) [15]: Computer Science, Computer Engineering, Software Engineering, Computing Degrees, and Information Systems. These references are not curricula, but rather reference materials designed to aid the preparation of curricula. They should be used alongside the MEC guidelines [16].

The ACM/IEEE Reference Curriculum [8] defines a framework of knowledge topics, and units to guide Computing education and training. It is used as a basis for teaching computing topics in many universities, is recognized and adopted internationally, and is widely used alongside other curriculum guides worldwide.

In the ACM/IEEE Reference Curriculum [8], software project management is fully incorporated into the "Users and Organizations" axis. These references are widely used to develop and maintain undergraduate curricula in subjects related to software engineering. The ACM/IEEE Guide outlines the core content for a software engineering curriculum and defines the subject-specific content.

III. Materials and Methods

According to Gil [17], scientific research is diverse and requires each study be classified according to its specific characteristics. In terms of its nature, this research is classified as primary because it involves observations in Computing PPCs, aiming to identify relevant information [18].

This study was based on the proposal made in [16] to select the Brazilian educational institutions whose curricula were analyzed. This proposal aimed to identify how the teaching of software testing in undergraduate Computing courses in Brazilian institutions had been approached through a curricular analysis.

The 2023 RUF ranking, the most recent at the time of writing this article, was used to select the universities. The RUF course ranking is an annual assessment of undergraduate courses at Brazilian universities, university centers, and colleges, based on national and international data from opinion surveys on education and the job market [6].

Based on the ranking positions, the score assigned by the MEC was verified to confirm compliance with the ranking score and to identify institutions offering Computing courses, the focus of this study. These courses have been regulated in Brazil by the SBC since the mid-1980s [19], and are offered by the institutions that perform best in the RUF. Finally, the accessibility of the curricular matrices was verified.

The intention was to work with the same number of universities as in [16], plus two more from the authors of this work. However, eight institutions did not meet the established inclusion criteria. Thus, 22 institutions were selected. The curricula, pedagogical plans, and syllabuses of these institutions were collected and, for each subject, content related to SPM was obtained. This will be detailed in Section IV of this study.

This study examined the curricular content of the leading Computing institutions in Brazil. Analysis of these matrices, made it possible to generate a knowledge framework that answered the following Research Questions (RQ):

- RQ-I: What software project management topics are included in the curricula?
- RQ-II: How are the subjects that deal with software project management organized in the universities' PPCs?
- RQ-III: How do the contents of the software project management subjects relate to the ACM/IEEE curriculum and PMBOK 7th Edition?

The aim of RQ-I is to identify topics and contents related to software project management in the PPCs of Brazilian, and to analyze the relationships between these topics. To this end, the the authors analyzed the teaching plans, syllabuses, or curricular matrices available on the institutions' websites to determine the contents offered in subjects specifically dealing with software project management. The results were then presented to a software engineering researcher with experience in creating academic curricula and teaching plans for evaluation.

Regarding RQ-II, the research question aims to verify how universities organize the contents of subjects dealing with project management, including workload and whether these subjects are mandatory or elective. The same analysis as in RQ-I was performed, but the content of each subject present in the curricular matrices of each institution was accessed. As with RQ-I, all the results obtained were evaluated by another Software Engineering researcher.

RQ-III aimed to compare the content indicated by the ACM/IEEE Guide, the PMBOK (7th Edition), and the PPCs of the institutions analyzed in this study. To this end, each institution's curricular matrix was analyzed in full to determine how software project management is taught. The curricula of each institution were examined to determine what topics relating to software project management were covered, in relation to the Curricular Guidelines for Undergraduate Courses in Software Engineering [8] and the PMBOK Guide 7th Edition [11].

Finally, the research results were presented to an independent researcher who had not participate in the extraction and analysis process, in order to certify the validity of the Project Management results. The chosen researcher has

20 years of experience in Software Engineering and Software Project Management, and has conducted research on Computer Education, applying the knowledge obtained to Software Project Management subjects in Computing courses.

IV. Results

A. Brazilian Institutions Selected

For this study, 30 institutions were initially considered, including the 28 highest-ranked institutions in the 2023 RUF, as well as the two institutions affiliated with the authors of this work: Federal University of Pará (UFPA) (71st) and Federal Rural University of the Amazon (UFRA) (301–350th). However, only 22 of these institutions were analyzed due to the availability of relevant data. While the aforementioned two universities are included in the ranking, this was not a selection criterion. It is worth noting that the number of institutions in the RUF ranking was based on [16].

The 28 best-placed institutions, i.e., those with the best Computing grades according to the 2023 RUF (the last survey carried out prior to the preparation of this work), are listed in Table 1.

Table 1. Selected universities

Brazilian Universities	Abreviation
State University of Campinas	Unicamp
University of São Paulo	USP
Federal University of Minas Gerais	UFMG
Federal University of Rio Grande do Sul	UFRGS
Federal University of Pernambuco	UFPE
Federal University of Rio de Janeiro	UFRJ
Federal Technological University of Paraná	UTFPR
Federal University of São Carlos	UFSCar
University of São Paulo	Unesp
Federal University of Paraná	UFPR
Federal University of Santa Catarina	UFSC
Pontifical Catholic University of Rio de Janeiro	PUC-Rio
Pontifical Catholic University of Rio Grande do Sul	PUCRS
Federal University of Campina Grande	UFCG
University of Brasília	UnB
Pontifical Catholic University of Minas Gerais	PUC-Minas
Pontifical Catholic University of Paraná	PUCPR
Federal University of Bahia	UFBA
Technological Institute of Aeronautics	ITA
Federal University of Ceará	UFC
Federal University of Amazonas	UFAM
Fluminense Federal University	UFF
Federal University of Uberlandia	UFU
Federal University of ABC Foundation	UFABC
Federal University of Mato Grosso	UFMT
State University of Maringá	EMU
Catholic University of Brasilia	UCB-DF
Federal University of Alagoas	UFAL
Federal University of Pará	UFPA
Federal Rural University of the Amazon	UFRA

Eight of the institutions listed in Table 1 do not mention Software Project Management, or any related subject or content: Unicamp, UFMG, UFRGS, PUC-Rio, PUCRS, PUC Minas, ITA, and UCB-DF. Therefore, only 22 institutions were included in the analysis to answer the research questions in the following subsections, as previous mentioned.

B. RQ-I: What Software Project Management Topics Are Included in the Curricula?

This research question aimed to identify the topics and content related to software project management included in Brazilian universities' PPCs, and to analyse the relationships between these topics.

Content was categorized based on a qualitative analysis of the PPCs content. Firstly, the recurring topics in each document were mapped, and how the content was structured and presented was observed. It is worth noting that some PPCs already contained this categorization. These structures thus served as a starting point for analyzing the others, which were not so explicitly organized.

References such as PMBOK (7th ed.) and SWEBOK (v4.0) were pivotal during the analysis process. While they were not used directly to create the categories, they helped to interpret certain content more effectively and understand how these topics are typically treated in the specialized literature. Therefore, it can be concluded that, while they served as conceptual support, the categories themselves emerged from the reading and interpretation of the PPCs.

The data organization followed a thematic coding process. As topics were identified, patterns, repetitions, and connections between them were sought. This mapping revealed frequently repeated thematic cores, which helped consolidate the categories. Ultimately, four categories were defined, as shown in Fig. 1. These categories were not chosen arbitrarily. They reflect what appeared most frequently in the PPCs and what is generally considered essential in software project management education.

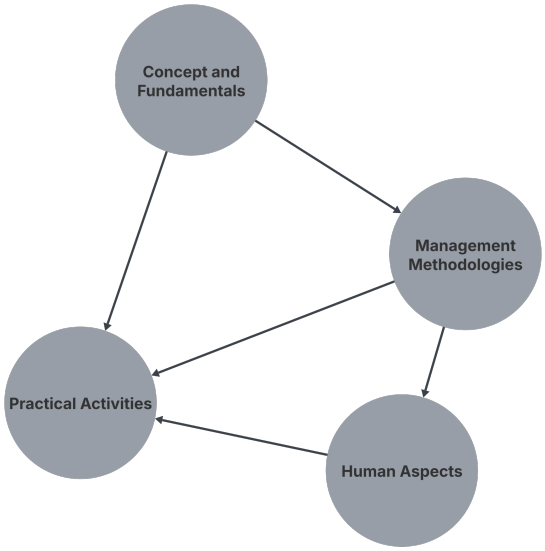

Fig. 1. Interrelationship of software project management topics identified in the PPCs.

Following the categorization phase, a more detailed analysis could be conducted to examine how these themes relate within each PPC. Reading each curriculum individually allowed certain patterns in the organization of content to be identified, leading to the creation of Figs. 1–4. These figures illustrate these relationships graphically. Fig. 1 shows that each vertex corresponds to a topic related to software project management. The connections between these points show how the topics are related within the PPCs. During the analysis, three categories were identified: Concepts and Fundamentals, Management Methodologies, and Human Aspects. In addition to these categories, a significant number of practical activities were observed, which were typically distributed throughout the course.

It should be noted that it is not possible to assert that all courses follow a rigid order, as there are variations. Generally,

however, they begin with basic concepts, then move on to methodologies—whether traditional, agile, or a combination of both—before addressing issues related to the human factor, such as teamwork, leadership, and stakeholder relationships. This structure suggests an intention to first establish students' conceptual foundations before progressing to practices and the more interpersonal aspects of management.

To complement this analysis, it is important to emphasize that the arrows in Figs. 1–4 indicate conceptual dependency relationships, or the inclusion of a subtopic within a broader theme. They should not be interpreted as a strict pedagogical sequence imposed by universities.

Building on the main topics presented in Fig. 1, it was possible to conduct a more in-depth analysis and identify additional relationships between the topics. Fig. 2 specifically details the topics covered in the concepts and fundamentals of software project management.

Unlike the main topics, however, it was not possible to determine the exact sequence in which the other topics were addressed. We only identified the present contents and their hierarchical relationships. For instance, the topic dealing with the project life cycle includes the following subtopics: Planning, Execution, and Monitoring and Delivering Value. Each of these topics has a further series of subtopics under its dependencies.

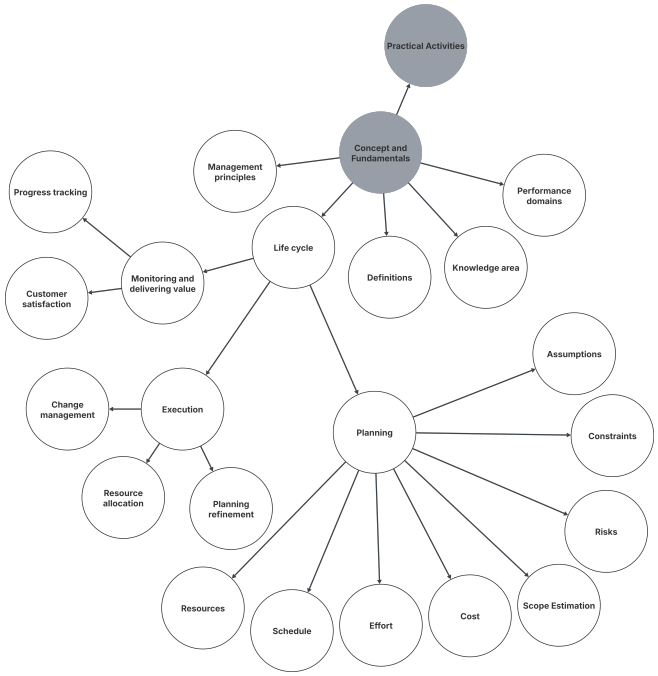

Fig. 2. Hierarchical and conceptual Interrelationships of the topics covered in Concepts and Fundamentals, without indicating a teaching sequence.

As shown in Fig. 2, in addition to the project life cycle topic, the concepts and fundamentals topic also covers definitions and principles of software project management, knowledge areas, and performance domains.

Fig. 3 shows that management methodologies, encompass several structures, often referred to as frameworks. Likewise, guides such as the PMBOK Guide stand out. Standards governing good management practices are also addressed, as exemplified by ISO 12.207, which deals with software life cycle processes. Models such as Capability Maturity Model Integration (CMMI) and Brazilian Software Process Improvement (MPS-BR), which focus on process improvement, are also included, as are several tools, processes, techniques, and methods.

With regard to the human aspects identified in the universities' PPCs, Fig. 4 shows that these documents address two main topics. The first topic covers the multicultural aspects of the people involved in the project, including issues of race and gender. The second point is stakeholder management. This indicates that universities seek to apply knowledge to satisfy those involved by considering the processes and structures used during management. Additionally, there is a focus on teamwork, aiming to evaluate team effectiveness and performance and associating it with self-management practices.

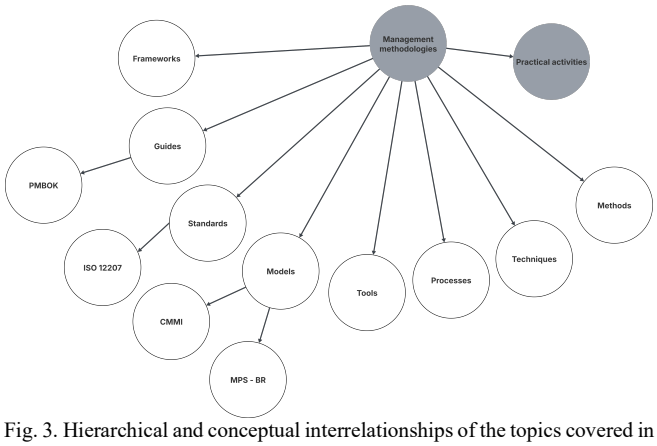

Fig. 3. Hierarchical and conceptual interrelationships of the topics covered in Management Methodologies, without indicating a teaching sequence.

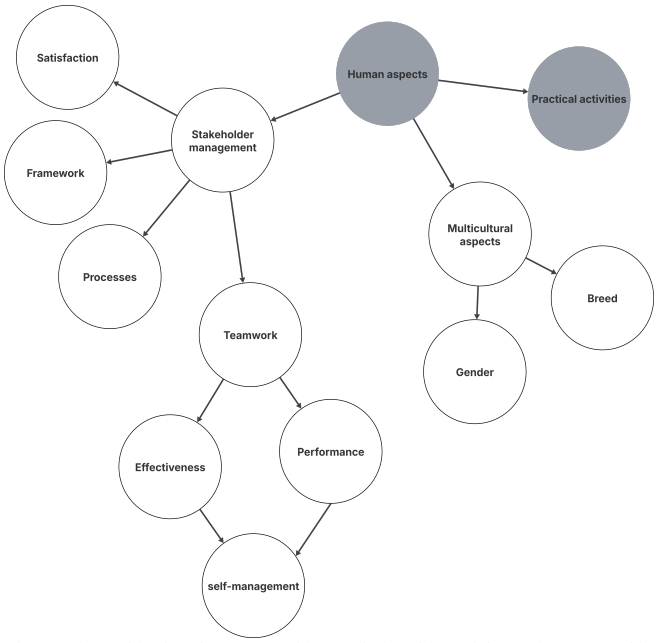

Fig. 4. Hierarchical and conceptual interrelationships of the topics covered in Human Aspects, without indicating a teaching sequence.

In general, universities organize topics into modules in order to teach project management and apply concepts to students. PPCs start with the fundamentals of project management, covering basic definitions. The project life cycle is then explained in detail, covering the phases of project management. Management methodologies, both traditional and agile, are presented alongside frameworks, standards, practical tools, and techniques.

The plan also includes a focus on human aspects, such as stakeholder management, diversity, teamwork, and

self-management. To consolidate learning, the programme incorporates practical activities and real case studies, enabling students to participate in project simulations and develop a final project that applies the acquired knowledge.

C. RQ-II: How Are the Subjects That Deal with Software Project Management Organized in Universities PPCs?

This research question aims to verify how universities organize the contents of subjects dealing with project management, such as workload per university, and whether these subjects are offered as mandatory or elective.

Based on Fig. 5, it can be seen that, of the 22 universities, 13 apply project management content to mandatory subjects, corresponding to 59% of the total. Conversely, only 41% of subjects are electives, meaning that 9 of the 22 universities offer these subjects as electives.

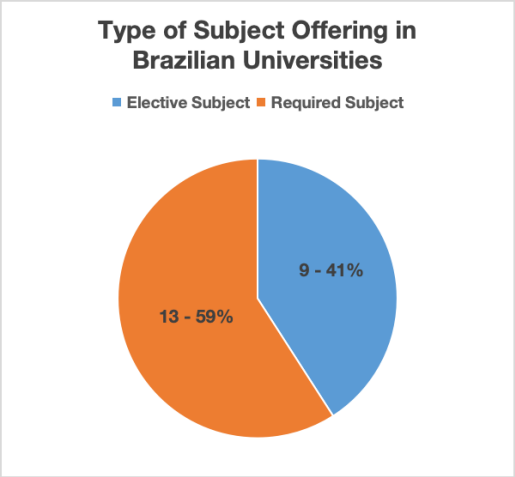

Fig. 5. How subjects are offered in courses.

As shown in Fig. 6, significant variations in course load were observed among project management courses at different universities. Of the 22 universities analyzed, only 17 provided information on course load in their PPCs. On average, universities offer courses with a load of 64 h.

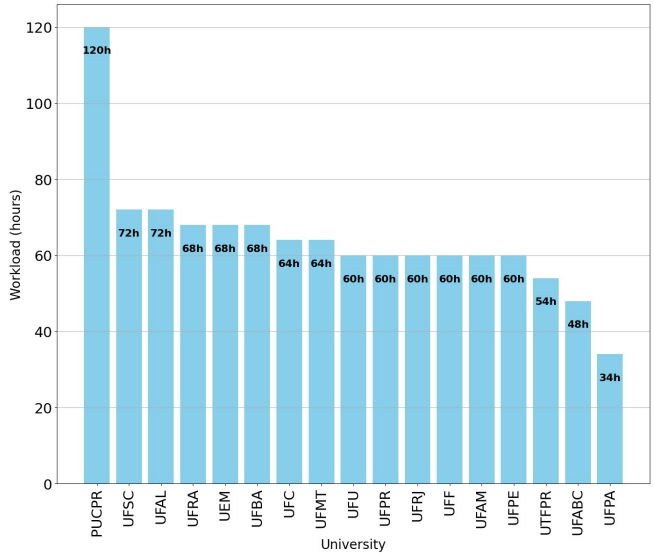

Fig. 6. Course loads at universities.

PUCPR stands out as the university with the largest workload, totaling 120 h. In contrast, UFPA has the smallest workload, totaling 34 h for the Project Management subject. Most universities offer courses with workloads between 60 h and 72 h. Only two universities offer courses with workloads below 48 h: UFABC and UFPA.

The analysis of workloads considered the total workload of participants, given that it is difficulty to quantify the specific time dedicated to project management when it forms part of a broader subject. This approach ensures the consistency and comparability of the data since PPCs do not always detail the distribution of hours for each topic. Attempting to estimate this division could introduce bias into the analysis and compromise the results. While a more detailed analysis would be interesting, it would require access to data which is often not publicly available.

Table 2 shows the names of subjects addressing software project management and how many universities use them. It should be noted that most of the content on software project management is offered within the Software Engineering subject, which may be divided into Software Engineering I and II.

Table 2. Name of the subjects that cover software project management content

Subjects	QTY
Software Engineering	7
Project Management	6
Project Management	2
Software Development	1
Project Planning and Management	1
Project Management and Agile Methods	1
Contemporary Management	1
Information Technology Project Management	1
Software Project Management	1
Elements of Software Project Management	1

For example, the topic “Software project management techniques” is covered in the Software Engineering II course at UFSCar. At UFPR, the topic “Software Project Management” is covered in the Software Engineering course. At UFCG, the Software Engineering I course covers the topic of “Software project management: estimates, risk analysis, scheduling and monitoring, quality verification”.

UFPE addresses the topic of “Introduction to Project Management” within the subject of “Software Development”. Other universities cover specific project management subjects, which vary only in name. For example, UFBA titled its subjects “Contemporary Management” and UFPA titled its as “Elements of Software Project Management”.

The terms “Project Management” and “Project Administration” were treated as equivalent, reflecting institutional naming preferences rather than conceptual differences. For example, UFRGS offers a course titled “Project Management and Administration”, which covers the same content as other “Project Management” courses. Therefore, both were analyzed under a unified thematic scope.

As can be seen in Fig. 7, only five universities provide the activity type applied in the offering of the subject in their PPCc: UFPE, UFRJ, UTFPR, UFPR, and UFPA. All of these universities offer the subject through theoretical classes. Furthermore, with the exception of UFPA, all the others dedicate part of their workload to practical classes. However, only UFPE and UTFPR incorporate practical activities in their subjects, thus including the three types of activity in their PPCs.

It is important to note the distinction here between what is

considered to be a practical class and a practical activity in the context of this research. Practical classes take place in a classroom or laboratory, with an instructor present to provide guidance. They involve applying theoretical knowledge in a controlled environment. In contrast, practical activities are carried out more autonomously outside the classroom and may include projects, case studies or applied exercises that lack the formal structure of a class.

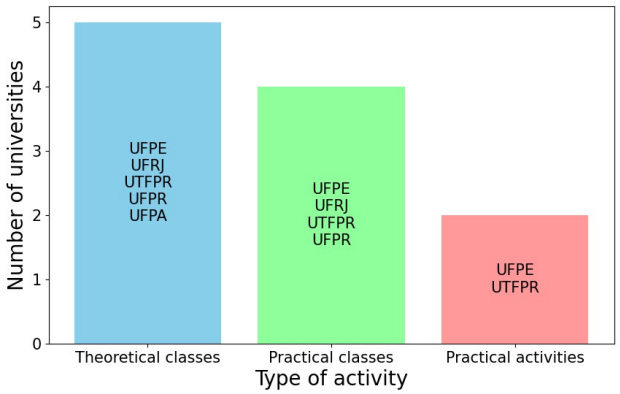

Fig. 7. Activity type count by university.

D. RQ-III: How Do the Contents of Software Project Management Courses Relate to the ACM/IEEE Curriculum and PMBOK 7th Edition?

The aim of this topic is to present a comparison of the content indicated by the ACM/IEEE Guide [8], the PMBOK 7th Edition [11], and the PPCs of the institutions analyzed in this study.

The ACM/IEEE curriculum outlines several essential topics for Software Project Management teaching. Key topics include:

- Software Processes: this topic involves defining, implementing, evaluating, and improving the processes used in software development and maintenance.,
- Software Project Management: this topic focuses on the practices of planning, monitoring, and controlling software projects, including estimation techniques, risk management, and quality management,
- Communication and Teamwork: this topic highlights the importance of communication and collaboration skills within software development teams,
- Development Tools and Environments: this topic highlights the use of tools and environments to support project management activities and ensure software quality,
- Human and Social Aspects of Software: this topic covers the ethical and professional aspects of software project management.

By comparing the ACM/IEEE guidelines on teaching Software Project Management with the PPCs of Brazilian universities, intersections were identified that reveal a convergence between global standards and national educational practices.

Brazilian universities structure their introductory content around the concepts and fundamentals of software project management. These include basic definitions, knowledge areas, and performance domains. This approach fully aligns with the ACM/IEEE recommendations, which emphasize the importance of a deep understanding of software processes.

The curriculum of Brazilian universities details the project life cycle, covering the planning, execution, and monitoring phases. This aspect is crucial, as recognized by the ACM/IEEE guidelines, which emphasize the importance of a well-structured life cycle for the success of software projects. The ACM/IEEE curriculum emphasizes the importance of planning, monitoring, and control practices, including estimation techniques, risk management, and quality assurance, all of which are covered by Brazilian universities.

Brazilian universities use management methodologies that include both traditional and agile frameworks, guidelines, standards, and process improvement models. This reflects the ACM/IEEE recommendations that teaching methodologies should allow students to adapt their practices to the specific needs of each project and organization [20].

Brazilian university curricula also emphasize the human aspects of project management. This aligns with ACM/IEEE guidelines, which emphasize the importance of effective communication and collaboration skills within software development teams. Furthermore, the ACM/IEEE acknowledges the necessity of addressing ethical and professional considerations in software project management.

The PMBOK 7th edition is a widely used guide project management guide covering a wide range of essential practices and principles. The following analysis compares the topics covered by the PMBOK with those covered by the ACM/IEEE and PPCs of Brazilian universities.

Both the ACM/IEEE and Brazilian universities focus on providing basic definitions of project management, covering essential knowledge areas and performance domains. The PMBOK 7th edition complements this approach by emphasizing project management principles, including the importance of delivering value and creating an environment of trust. It also details knowledge areas such as Integration, Scope, Time, Cost, Quality, Resources, Communications, Risk, Procurement, and Stakeholders, offering a comprehensive and practical overview of these areas [11, 21, 22].

The ACM/IEEE and Brazilian university curricula cover the different phases of the project life cycle, including planning, execution, and monitoring. This approach aligns with the PMBOK 7th edition, which outlines these phases and the key processes of the project life cycle, emphasizing how these processes interact and are applied. Additionally, the PMBOK emphasizes adaptability to the project context, which is a vital component of effective project management in many environments and circumstances [11].

Both Brazilian universities and the ACM/IEEE include traditional and agile frameworks, as well as important guides and standards such as the PMBOK, ISO/IEC 12.207, CMMI-Dev, and MPS-BR. The PMBOK 7th edition builds on by incorporating agile, hybrid, and predictive methodologies and emphasizing the importance of adapting the management approach according to the nature and specific requirements of each project [23].

Stakeholder management, diversity, teamwork, and self-management are central components of both ACM/IEEE and Brazilian university curricula. The PMBOK 7th edition reinforces these aspects by emphasizing the importance of leading and motivating teams, managing stakeholders to create and maintain beneficial relationships, and valuing

organizational culture and human factors [22].

ACM/IEEE and Brazilian universities strongly emphasize the practical application of knowledge through activities, case studies, and project simulations. The PMBOK 7th edition reinforces this approach by emphasizing the application of knowledge and the use of specific tools and techniques to enhance project management practice [21].

A comparison reveals a high degree of alignment between the ACM/IEEE, Brazilian universities, and the PMBOK 7th edition guidelines, each of which makes a unique contribution to the comprehensive training of software project managers. Integrating these approaches could provide a more robust education that is aligned with best practices, effectively preparing students for the challenges of the job market.

V. Discussion

A. Content Organization

The results of this study provide a detailed overview of how Brazilian universities approach teaching of project management, highlighting the variations and common patterns identified.

Of the 22 universities considered in this study, 59% offered project management courses as mandatory, while 41% offered them as electives. This suggests that, while most institutions recognize the importance of project management in students' education, a significant proportion still treat this knowledge as optional. Mandatory courses may reflect the university's emphasis on this skill, while elective courses may indicate greater curricular flexibility within the programme.

The number of hours devoting to teaching project management subjects varies significantly between universities. This variation may indicate different pedagogical approaches and depth to which content is covered. Universities with fewer hours may limit the scope of topics covered, whereas those with more hours may offer more in-depth coverage.

The table of subject names shows that many subjects cover software project management topics, with "Software Engineering" being the most common. This suggests that many universities prefer to integrate these topics into broader subjects rather than offering specific courses on them. This diversity may also reflect different curricular approaches and attempts to align courses with market demands.

The results highlight the need for greater standardization and in-depth study of how project management courses are offered at Brazilian universities. Disparities in course load, variation in the mandatory nature of courses, and differences in the application of practical activities show that, although the importance of project management is recognized, its implementation in curricular still varies significantly.

B. Relationship between the PPCs, ACM/IEEE, and PMBOK

Analyzing the curricula of ACM/IEEE, Brazilian universities, and the PMBOK 7th edition revealed areas for improvement in order to better prepare students.

Brazilian university curricula place a strong emphasis on project management concepts and fundamentals. This aligns with the ACM/IEEE, which also emphasizes the importance of understanding the basic definitions and key knowledge areas for project management practice. However, while Brazilian universities comprehensively cover these aspects, they often do so theoretically. They could benefit from integration the principles detailed in the PMBOK 7th edition more practically, as highlighted in [24].

The structure of university curricula around the project life cycle—including planning, execution, and monitoring—aligns with the practices recommended by the ACM/IEEE and the PMBOK. However, adaptability to the project context, which is emphasized in PMBOK [23], is an area that could be explored further in future studies. The ability to adapt processes and methodologies to the specific needs of each project is essential, and this could be reinforced through the use of more case studies and varied simulations [25].

The management methodologies taught at Brazilian universities, including traditional and agile frameworks as well as standards and models, demonstrate the importance universities attach to this topic. However, the integration of hybrid and predictive methodologies, as emphasized in the PMBOK, requires further exploration. The PMBOK emphasizes the need for flexibility in project management [23], which is essential in the software development environment and should be more explicitly incorporated into the academic curriculum, as pointed out in [26].

Both ACM/IEEE guidelines and Brazilian university curricula address the human aspects of project management well, such as stakeholder management, diversity, teamwork, and self-management. However, the PMBOK not only highlights the importance of these elements, but also the need for effective leadership and the creation of an environment of trust and collaboration, as discussed in [21]. Although this dimension of leadership and organizational culture is mentioned in the curricula, it could be emphasized more practically through leadership exercises, continuous feedback, and team performance evaluations in real projects.

Finally, Brazilian university curricula's strong point is the integration of practical activities and case studies, which is in line with the recommendations of the ACM/IEEE and PMBOK. The practical application of theoretical knowledge is essential for consolidating learning and preparing students for real-world challenges [27]. However, the PMBOK suggests the extensive use of specific tools and techniques [22], which could be incorporated more systematically into academic programmes to ensure students understand and can apply these tools in project management.

In conclusion, while Brazilian university curricula are well aligned with ACM/IEEE guidelines and cover many essential project management principles and practices, there are opportunities for deeper and more practical integration of the elements highlighted by the PMBOK 7th edition. Greater methodological flexibility, a stronger focus on leadership and organizational culture, and a more systematic application of specific tools and techniques, curricula could better prepare students for the challenges of software project management in an ever-evolving technology industry.

VI. Threats to Validity

This section aims to analyze the threats to the study's validity, as well as the mitigation strategies. To this end, the four aspects of validity defined in [28] were used.

A. Internal Validity

The analysis of the syllabuses and PPCs of each course was carried out by one of the researchers. However, after the information had been extracted, another researcher who had not participated in the analysis process validated the results to ensure they were adequate for the objective of the work.

B. External Validity

To mitigate risks related to external validity, the methodology and selection criteria for subjects and educational institutions were detailed in Section III.

Further supporting the external validity of our approach, several previous studies in the Brazilian context have successfully employed similar methodologies for analyzing curriculum content of undergraduate courses in related computing domains, aiming to diagnose the SPM area. For instance, Elgrably and Oliveira [16] applied syllabus and PPC analysis to investigate the teaching of software testing, while Castro and Oliveira [29] used a comparable approach based on ENADE scores to examine software design education. The fact that these established methodologies yielded meaningful insights in analogous domains strengthens the credibility of applying our methodology to diagnose SPM teaching.

C. Construct Validity

The theoretical framework used to analyze the syllabuses was the PMBOK (Project Management Body of Knowledge), a well-known guide to project management, as well as the curriculum made available by ACM/IEEE. Verifying the inclusion of these contents in the syllabuses demonstrates an alignment of the PPCs' contents with the basic references of Software Project Management in Computing courses.

D. Conclusion Validity

In order to mitigate threats to the validity of the conclusion, the researcher analyzed the course syllabuses, ensuring that non-explicit subtopics were not included. To this end, a mind map detailing the specific content of the subtopics was developed to facilitate the analysis and avoid the inclusion of related subtopics not present in the syllabuses. Another mitigation measure was to conduct the review process with a second researcher who did not participate in the initial analysis of the syllabuses.

VII. Conclusion

This research aims to contribute to the development of project management education in Brazil by presenting a diagnosis of SPM content in the country's leading institutions. The analysis of the results revealed that different researchers had covered many topics, including the subjects with SPM content and their alignment with the curricula.

Regarding RQ-I, a clear division of content was observed in university curricula. Institutions address fundamental concepts in the field, applying methodologies, frameworks, models and standards, while also focusing on human aspects such as race and gender. These topics are complemented by practical activities throughout the course to ensure comprehensive, integrated education.

Regarding RQ-II, the analysis revealed a diverse organizational structure, with most universities offering these courses as compulsory modules. Course loads vary significantly, averaging 64 h. The content is often integrated into Software Engineering subjects, but also appears in specific courses under different names. Additionally, some universities combine theoretical and practical classes, while others focus exclusively on theory. These variations suggest that institutions are attempting to adapt the teaching of software project management to their own specific circumstances and requirements.

Finally, RQ-III demonstrated a high level of alignment with the ACM/IEEE curriculum guidelines and the PMBOK 7th edition in the area of software project management teaching. Universities that adopt this approach cover fundamental concepts, management methodologies, and human aspects, thereby aligning with global best practices. This integration of theoretical and practical content effectively prepares students for the challenges of the job market, providing them with a robust and comprehensive education.

The authors clarify that their intention is not to criticize the curricular matrices of Brazilian educational institutions, but rather to suggest ways in which curricula can be improved and adapted, and to provide content and references that can be used in curriculum construction.

Future work will involve replicating the methodology by analyzing SPM teaching ate leading universities worldwide. The study will also be replicated in other Brazilian technology courses recommended by SBC, and the similarities and discrepancies in SPM teaching will be analyzed. Finally, the study will be expanded by adopting an approach that combines the perspectives of instructors and students on software project management courses as applied in their respective contexts.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

E.C.C.: Conceptualization, Methodology, Formal analysis, Investigation, Writing—original draft preparation; S.R.B.O.: Conceptualization, Validation, Writing—review and editing, Supervision. F.W.S.G.: Conceptualization, Validation, Supervision. All authors had approved the final version.

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