Content and Skills for Teaching BPM in Computer Science Courses: A Systematic Mapping Study

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Abstract: The increasing demand for professionals in Business Process Management (BPM) highlights the need to align technical skills developed in education with market requirements, revealing a gap that requires investigating the essential content and skills for BPM education. This work aims to understand the content and skills addressed in BPM education, contributing substantially to understanding the current academic landscape of BPM. We conducted a systematic literature review to investigate the state of the art regarding BPM education. We also compared the content of the curriculum guidelines of the Brazilian Computing Society (SBC) and Business Process Management Common Body of Knowledge (BPM CBOK). In addition to providing a critical analysis of trends and gaps in the literature, this work offers insights that can be applied to enhance education in the field of BPM. The expectation is that the results obtained can inform the better training of professionals, aligning them effectively with the dynamic and specific market needs in terms of efficient BPM, thus promoting integration between theory and practice in the academic and professional context.

1 INTRODUCTION

The teaching of Business Process Management (BPM), a concept solidified by the global trend of process-based management, encounters challenges in ensuring requisite content and skills within professional training. This complexity arises as BPM extends beyond supportive tools, encompassing the integration of knowledge and practical application (Moormann and Bandara, 2012). The intricate nature of processes, exemplified by events, activities, decision points, and multiple actors, underscores BPM's dynamic interaction with organizational elements and outcomes (Dumas et al., 2012).

Despite BPM's maturity as a discipline, persistent challenges, such as the misalignment between education and anticipated job market skills, accentuate the necessity of aligning educational curricula with BPM professional requirements (Delavari et al., 2010). These gaps have repercussions for educational institutions and individuals, punctuating the significance of overcoming obstacles in defining curricula and implementing programs aligned with practical realities.

As market demands evolve, it becomes imperative to identify specific content for dissemination and delineate the essential skills professionals must cultivate to apply BPM in real-world scenarios effectively. Moreover, this study's motivation extends to exploring innovative and adaptable teaching methods capable of integrating technological transformations that continue to shape BPM education.

Curriculum guidelines are crucial in developing Pedagogical Projects for Courses within Higher Education Institutions (Colares, Furtado, and Oliveira, 2023). Within this educational framework, organizations like the Association for Computing Machinery (ACM), the Institute of Electrical and Electronics Engineers (IEEE), and the Brazilian Computing Society (SBC) are prominent for offering curriculum guidelines for courses in the computing domain (Colares, Furtado, and Oliveira, 2023). Furthermore, it's vital to incorporate the best practices outlined in the BPM CBOK (Business Process Management Common Body of Knowledge).

The absence of consensus in defining a standardized BPM curriculum for educational institutions and the challenges in aligning programs with industry dynamics emerge as critical issues in this study. This gap has significant implications for educational in-

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stitutions and students seeking a foundational understanding of BPM capabilities, emphasizing the inevitability of a thorough investigation.

Motivated by this context, the following research questions guide this work:

RQ1: How has Business Process Management (BPM) been taught? We conducted a Systematic Mapping Study (SMS) to understand the content, developed skills, teaching methods, technological support, and challenges faced in the training process.

RQ2: How do current BPM (Business Process Management) educational programs align with the curricular guidelines provided by the SBC and the BPM CBOK in computing courses?" To answer this question, we compared the content of the curriculum guidelines of SBC and BPM CBOK.

Therefore, the study contributes to a comprehensive understanding of the BPM education landscape by gathering different perspectives on the topic and comparing them with the curricular guidelines of institutions that regulate BPM education in computing courses, Brazilian Computing Society (SBC) and Business Process Management Common Body of Knowledge Guide (BPM CBOK), respectively.

To report this research, this paper is organized into five Sections. In Section 2, we discuss background and related works. Section 3 details the research methodology. In Section 4, we provide answers to the research questions. Finally, in Section 5, we present conclusions and future work.

2 BACKGROUND

This Section provides critical perspectives on the landscape of BPM education. We will discuss the need for sophisticated methods to navigate intricate business processes, emphasizing the strategic importance of BPM. We will analyze existing literature reviews on the subject, identifying critical facets such as guidelines for successful teaching and the growing demand for competent BPM professionals.

This highlights the relevance of a more comprehensive Systematic Mapping Study (SMS), considering the different gaps identified in the studies conducted so far and their alignment with the curricular guidelines for BPM education. Finally, we will examine some teaching methodologies that categorize approaches, emphasizing the evolving roles of students and the integration of Bloom's taxonomy for more refined learning objectives in BPM education.

2.1 Business Process Management (BPM)

Contemporary BPM is dealing with a dynamic and challenging environment due to factors like globalization, technological innovation, and the information explosion (Pasha, 2013). As business processes vary in complexity, with some being knowledge-intensive and deeply integrated into organizational practices, BPM becomes a competitive tool in modern business. This emphasizes the need for structured methods and technologies to manage multi-functional processes continuously. Van Der Aalst (2012) adds to this understanding, defining BPM as the discipline that combines knowledge of information technology and management sciences applied to operational business processes. The holistic view of BPM aims to improve these processes, often using modeling and simulation for optimization.

2.2 BPM CBOK

The *Business Process Management Common Body of Knowledge Guide (BPM CBOK)*[1] was developed by ABPMP International to provide an overview of best practices in the BPM market. It defines four knowledge areas: Business Process Management, Process Management Organization, Enterprise Process Management, and Business Process Management Technologies.

The BPM knowledge area is divided into five subareas: Process Modeling, Process Analysis, Process Design, Process Performance Management, and Process Transformation.

2.3 SBC Computing Training Reference

The Brazilian Computing Society (SBC) [2] is a nonprofit organization that brings together professionals and enthusiasts in the field of Computing and Informatics in Brazil. It promotes access to information culture and encourages research and education.

The SBC guides computer education, influencing the National Curricular Guidelines (NCGs) (Zorzo et al., 2017). To provide this guidance, its internal committees are responsible for the preparation and approval of the "References for Training in Computing" (RF), which are required to adhere to the NCGs and employ a competency-based model(Zorzo et al., 2017).

The RF framework is segmented into three principal components (Zorzo et al., 2017): Training Axis,

[1] https://www.abpmp.org/page/guide_BPM_CBOK

[2] https://www.sbc.org.br/

Derived Competencies, and Specific Content. The Training Axis encompasses a collection of skills pertinent to a particular field of knowledge. Derived Competencies are skills that emerge from the Training Axis, offering more granular and detailed insights. Lastly, Specific Content pertains to the distinct materials associated with the competencies and the Training Axis. This content is structured to enable learners to grasp the requisite knowledge and skills essential for cultivating the competencies demanded by the Training Axis (Zorzo et al., 2017).

2.4 Related Works

Following an exploratory study on BPM education, a dearth of other SMS on teaching BPM became apparent. Four literature reviews were identified, each addressing specific facets. In the initial study by Marjanovic and Bandara (2011), guidelines for BPM success were scrutinized, emphasizing the imperative for qualified professionals. The persistent issue of inadequate BPM education was underscored, highlighting the urgency of a higher education approach, particularly integrating BPM courses into computer science undergraduate curricula.

In the second study, Bandara et al. (2013) delved into the intricacies of BPM initiatives, spotlighting the emergence of new roles and tasks. The global demand for qualified professionals spurred increased BPM courses offered by educational institutions. The third study, conducted by Silva and Thom (2021), reinforced the heightened pursuit of skilled professionals across all phases of the BPM lifecycle.

Delavari et al.'s (2010) study centered on the disparity between BPM education in Australia and the skills demanded by the industry, shedding light on challenges such as the absence of consensus on BPM implications. Comparing these studies with the objectives of this SMS mentioned in the previous Section, it becomes evident that there are distinct emphases and contributions.

2.5 Teaching Methodology

The study conducted by Brighenti et al. (2015) classifies teaching methodologies into collective, group, individualized, and socialized-individualized approaches. Collective methods deliver instruction to groups, emphasizing shared learning experiences, while group methods prioritize student interaction. Individualized methods tailor instruction to meet the specific needs of each student, and the socialized-individualized approach combines both group and individual work (Brighenti et al., 2015).

Diesel et al. (2017) pinpoint intersections between active teaching methodologies and educational practices. The text underscores the increasing prevalence of active methodologies in international universities, highlighting their integration into Brazilian institutions. The paper emphasizes the transformation in the role of students in BPM education, with a particular focus on active methodologies.

In BPM education, the work of Pasha (2013) employs Bloom's taxonomy to articulate learning objectives, categorizing them within the cognitive domain across six main areas: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. The revised taxonomy structure encompasses Factual, Conceptual, Procedural, and Metacognitive Knowledge.

3 METHOD

We selected an exploratory research approach similar to the work of Luz et al. (2022) because our objective is to uncover the methods, teaching practices, materials utilized, and other pedagogical mechanisms that could enhance the teaching of BPM.

The methodology adopted in this paper comprises two steps. First, we conducted a Systematic Mapping Study (SMS) following Kitchenham and Charters (2007) guidelines to answer RQ1. Secondly, we performed a content analysis of SBC and BPM CBOK documents to answer RQ2.

3.1 Systematic Mapping Study

Kitchenham and Charters (2007) define a Systematic Mapping Study (SMS) as a comprehensive system for acquiring information that describes, compares, or elucidates knowledge, attitudes, and behaviors, often presented in questionnaire format. The authors emphasize that SMS is a method to identify, assess and interpret all relevant available research for a research question, aiming to provide an accurate assessment through a reliable methodology.

This SMS aims to identify the essential content and skills for promoting BPM education, seeking a comprehensive understanding of how BPM concepts are taught. To address this, Specific Research Questions (SRQs) have been formulated to guide the synthesis of results, which are presented in Table 1.

Table 1: Specific Research Questions.

Identifier	Research Sub-question
SRQ1	What is the main content covered in BPM education?
SRQ2	What are the key skills developed in BPM education?
SRQ3	What are the teaching methods for conveying BPM knowledge?
SRQ4	How do technologies support BPM education?
SRQ5	What are the main challenges in the training of BPM professionals?

3.1.1 Search Strategy

We chose research sources based on their relevance to Software Engineering. Thus, the SMS was initially conducted across four research sources: ACM Digital Library, IEEEXplore, ScienceDirect, and Scopus. To identify papers through an automated search, we used the following search string:

(BPM OR "Business Process Management") AND (Education OR Teaching OR Learning OR Training)

We tested various combinations of terms and synonyms to determine the search string used. We opted for the terms "BPM" and "Business Process Management" as they are commonly utilized in this area. We selected synonymous terms such as "Education", "Teaching", "Learning", and "Training" because numerous papers not only addressed the teaching of BPM but also explored BPM techniques used to optimize the teaching process.

We restricted the search to publications from 2013 to 2023, to focus the analysis on a relevant timeframe for developing the research topic, considering changes, advancements, or significant events over time in the area of interest for this study.

3.1.2 Selection Criteria

We used the inclusion and exclusion criteria in Table 2 to select the studies.

Table 2: Inclusion and Exclusion Criteria.

Identifier	**Inclusion criteria**
CI1	Papers related to the theme and research questions.
CI2	Papers within the chosen research period (2013 to 2023).
CI3	Papers referencing versions 3 or 4 of the BPM CBOK.
Identifier	**Exclusion criteria**
CE1	Papers outside the chosen research period (2013 to 2023).
CE2	Secondary papers (other SLR or SMS).
CE3	Papers with fewer than four pages.
CE4	Duplicate or similar papers.
CE5	Papers not written in English.

The search selection process occurred in three steps. Step 1: read titles, abstracts, and keywords. Step 2: Read the introduction and conclusion. Step 3: the selected studies were thoroughly read, excluding papers irrelevant to the research questions.

3.1.3 Quality Assessment

To analyze the quality of the selected articles, we classified the studies according to the following quality criteria already used by the literature (Dermeval et al., 2016): "Clear Context", "Well-Defined Methodology", "Related Work", "Relevant and Consistent Discussion", and "Commented Research Limitations and Threats."

The quality criteria were scored based on the following values: a score of 0 would be assigned if the article did not meet the criterion, 0.5 would be granted if the article partially met the criterion, and a score of 1.0 would be assigned if the article fully met the criterion. Thus, the maximum possible score for the total article evaluation would be 5.0. We adopted a minimum score of 60%; hence, articles scoring below 3.0 would be excluded from the review process.

3.1.4 Data Collection and Replicability

A data collection form was developed for the selected articles.Variables included details such as "Title", "Authors" and "Year of Publication". Quality criteria were incorporated to facilitate result synthesis, with colors indicating approval or disapproval. A repository was established to present the spreadsheet and the final list of articles, including links for replication, available in this link in line with scientific rigor and data sharing standards (DAFOE, 2014).

3.2 Document Analysis

To answer RQ2, we compared the SMS results with the national curriculum guidelines outlined in the Reference Framework for Undergraduate Computing Courses of 2017 (the most current reference curriculum available on the official SBC website) developed by SBC and the Essential BPM Curriculum defined in CBOK 4.0.

4 RESULTS

This section presents the results of our research questions. Each aspect is examined individually, providing a thorough understanding of the findings and consolidating the contributions of the selected studies to the research area.

4.1 RQ1: How Has Business Process Management (BPM) Been Taught?

First, we provide an overview of the selected studies, including insights into the data collection process, selection criteria, quality analysis, and data synthesis. The next subsections answer the research questions of our SMS listed in Table 1.

4.1.1 Studies Overview

The selected research sources returned the following outcomes: ACM DL yielded 67 results, IEEEXplore contributed 178 results, ScienceDirect generated 203 results, and Scopus, the most comprehensive source, returned 1226 results. This amounted to a total of 1674 initially identified articles.

After applying inclusion and exclusion criteria, we conducted an initial filter on titles and abstracts according to Table 3, resulting in the selection of 32 articles, comprising three from ACM DL, five from IEEEXplore, two from ScienceDirect, and 22 from Scopus. For some inconclusive publications, a second filter was applied to introductions and conclusions, maintaining the same criteria and including three more articles from Scopus. In total, 35 articles were selected.

Table 3: Collection Process Evolution.

Source	Initial	Filter 1	Filter 2	Filter 3	Final
ACM DL	67	3	0	3	1
IEEEXplore	178	5	0	5	5
ScienceDirect	203	2	0	2	1
Scopus	1226	22	3	25	14

We proceeded with the application of the quality criteria as a third filter. This process resulted in the final qualification of 21 papers for our research, distributed as follows: 1 paper from ACM DL, 5 from IEEEXplore, 1 from ScienceDirect, and 14 from Scopus. Table 11 (Appendix) contains the final list of selected papers.

Figure 1 illustrates the scores resulting from the quality analysis applied to the final articles selected in this study. Most articles (15) received scores ranging from 3.5 to 4.5 points, indicating substantial quality. Additionally, three articles (A7, A15, and A18) reached the minimum score of 3 points required for qualification. In comparison, only two articles (A8, A14) achieved the maximum score of 5 points.

Figure 2 demonstrates a progressive increase in the number of articles from 2013, going from a single article to four articles in 2015, with the majority of articles qualified for this research totaling four. Subsequently, there was a decrease until 2017, followed by a stabilization at two articles per year from 2019.

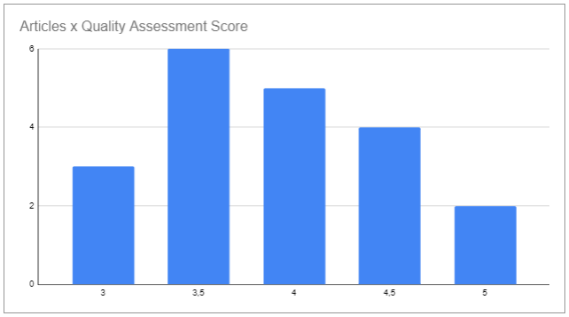

Figure 1: Articles x Quality Assessment Score.

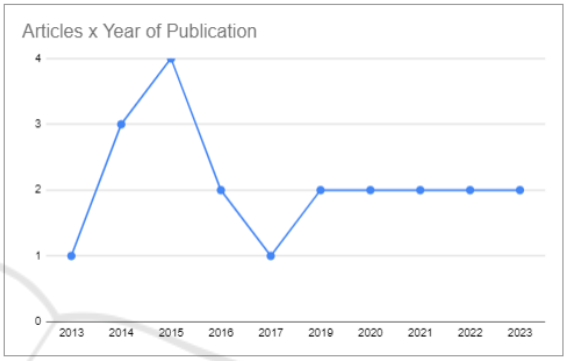

Figure 2: Articles x Year of Publication.

Figure 3 depicts the analysis of the geographical distribution of the selected articles. Each time a country of origin was identified for a particular author during the data collection, their contribution was recorded. It is essential to highlight that some of the analyzed studies resulted from collaborations among researchers from different countries, and the nationality of each author was considered individually to generate this figure.

This analysis reveals that the predominant academic contributions to BPM teaching originate from European countries. Among these, seven authors who conducted the studies are from Germany, followed by three from France. Researchers from Switzerland,

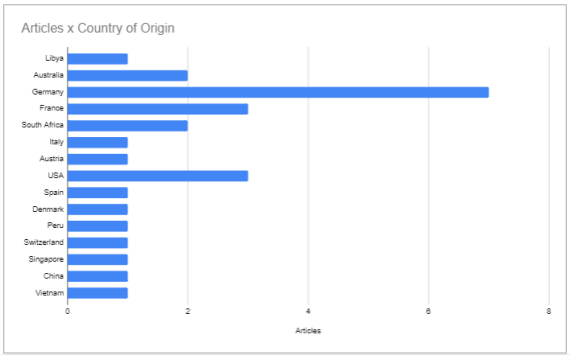

Figure 3: Articles x Country of Origin.

Denmark, Spain, Austria, and Italy contributed to different studies.

It is important to highlight that three researchers from the United States authored some of the selected articles, while two are from South Africa, one from Libya, and another two from Australia. Three Asian authors were identified, one from China, Singapore and Vietnam. Only one Latin American author was accounted for among the qualified articles from Peru.

The curriculum for BPM education encompasses different dimensions, each associated with distinctive tasks to provide a practical and in-depth understanding of BPM principles. We formulated five specific research questions described in Table 1 to identify the necessary contents and competencies for promoting BPM education.

4.1.2 SRQ1: What Is the Main Content Covered in BPM Education?

The SMS unveiled a variety of content covered in the teaching of BPM. It is important to emphasize that the codes for the articles mentioned in the following Sections are described in the "Identifier" column of Table 4. Among the 20 articles directly addressing this specific research question, we identified five main contents covered in BPM education, as indicated in Table 4.

Table 4: Main contents covered in teaching BPM.

Identifier	Content	Citations	Total
CO1	Introduction to BPM	A1, A2, A3, A10, A14	5
CO2	Business Process Modeling	A5, A12, A13, A16, A20	5
CO3	Business Processes in Technologies	A4, A15, A18	3
CO4	Performance in Business Processes	A9, A17, A19	3
CO5	Interdisciplinarity of BPM	A6, A21	2

The Introduction to BPM (CO1) primarily covers traditional teaching content, focusing on the business process life cycle (A1, A2, A3). A10 explores Serious Games (SG), introducing the Paper Game as a structured method. A14 suggests integrating BPM into university curricula using the Paper Game, accelerating learning.

In Business Process Modeling (CO2), A16 discusses content and pedagogy, introducing analytics in modeling courses. A20 proposes dramatization for business processes and ERP system learning. A5 emphasizes IBM's INNOV8 for process modeling. A12 and A13 present a board game to motivate students to learn modeling interactively.

For Business Processes in Technologies (CO3), A15 explores Digital Game-Based Learning in Information Systems, while A4 introduces Social BPM. A18 focuses on teaching execution and process knowledge through e-learning.

Concerning Performance in Business Processes (CO4), A9 introduces a university course empowering information systems students. A17 evaluates the impact of feedback on simulation games, like INNOV8, while A19 analyzes real-time feedback with INNOV8.

Regarding Interdisciplinarity in BPM (CO5), A6 highlights the challenge of varied focuses in different schools. A21 introduces teaching cases to develop a holistic view of processes.

These articles contribute to a diverse understanding of BPM education, emphasizing various pedagogical approaches and tools for effective learning.

4.1.3 SRQ2: What Are the Key Skills Developed in BPM Education?

BPM teaching encompasses various fundamental competencies for students' education and professional training. Among the 20 articles addressing this research question, we identified six key competencies developed in BPM education, as outlined in Table 5.

Table 5: Main skills developed in teaching BPM.

Identifier	Skills	Citations	Total
SK1	Model, analyze, design and implement business processes	A3, A21, A10, A12, A13	5
SK2	Work with BPM support tools	A1, A11, A16	3
SK3	Develop interpersonal skills	A4, A6, A18	3
SK4	Develop interdisciplinary skills	A5, A7, A14	3
SK5	Manage a business process	A19, A20	2
SK6	Close observation of processes in organizations	A19, A20	2

Regarding SK1, article A3 focuses on the BPM project lifecycle, providing a comprehensive understanding of identification and process monitoring. A21 presents a case study aimed at developing process modeling skills for undergraduates, postgraduates, and professionals enrolling students in a university.

A10 underscores the effectiveness of the Paper Game, a simulation game, in enhancing practical understanding of business processes. A12 introduces the BPMN Wheel game, emphasizing its versatility. A13 describes the same game as a simulation with learning and modeling phases, teaching theoretical fundamen-

tals applied to business process modeling.

Moving to BPM support tools (SK2), A1 highlights hands-on practice using Signavio Academic for practical exercises, contributing to advanced skills development. A16 mentions Signavio Process Editor for learning process modeling and solution design. A11 introduces Model Judge, a web platform aiding students in process modeling and instructors in agile exercise creation.

Concerning interpersonal skills (SK3), A6 highlights the diversity of skills required for Business Process Analysts (BPA). A18 explores situated learning in BPM logic, suggesting its potential effectiveness. A4 describes using social software and the Horus tool in labs focusing on process modeling.

For interdisciplinary skills (SK4), A7 emphasizes gaps in BPM training, stressing the importance of interdisciplinary education. A5 discusses using INNOV8, adopting a multidisciplinary approach with a 3D experience for teaching BPM.

Managing a business process (SK5) is discussed in A20, where group dramatization is employed to engage students in learning key steps, functional areas, and process management. A19 explores students' perception of simulation games, highlighting the application of prior knowledge to solve process management problems.

Close observation of processes in organizations (SK6) is covered in the university course "BPM and Organizational Practice" (A9), aiming to shape reflective process professionals. A15 discusses the study of INNOV8, demonstrating its potential to increase intrinsic motivation among students in the course.

BPM education integrates theoretical and practical competencies, utilizing tools, labs, and serious games. Interpersonal skills and understanding of the organizational context are emphasized to prepare students for practical challenges in BPM.

4.1.4 SRQ3: What Are the Teaching Methods for Conveying BPM Knowledge?

The teaching and assessment of BPM knowledge can employ various methods tailored to the student's needs. Nineteen articles directly address this issue, and to define the teaching methods, we rely on the classification by Brighenti et al. (2015) as their categorization enables the analysis of results in studies ensuring the transmission of BPM knowledge, as indicated in Table 6.

Table 6: BPM teaching methods.

Identifier	Method	Citations	Total
MT1	Socialized-individualizing teaching method	A4, A5, A12, A13, A15, A17, A18	7
MT2	Group teaching method	A1, A10, A14, A19, A20	5
MT3	Collective teaching method	A7, A9, A16	3
MT4	Individualized teaching method	A2, A3	2

The text outlines various innovative approaches in BPM education. In MT1, A18 advocates for practical methods with hands-on tasks, utilizing pre and post-tests in both e-learning and in-person settings. A4 introduces the Horus Method in a BPM Social Lab, while A5 enhances learning with simulated challenges using INNOV8. A15 incorporates INNOV8 toward the end of the BPM course. A12 tests the BPMN Wheel game, showing improvements in model quality.

MT2 highlights a dramatization exercise (A20) that significantly increases students' knowledge. In A1, a gamified approach is explored, with A10 emphasizing the early use of the Paper Game and A14 assessing understanding with pre and post-tests. A19 stresses the importance of feedback in simulation games.

In MT3, A7 suggests an interdisciplinary approach, combining online and in-person training. A9 describes teaching methods at renowned universities, integrating theory and practice. A16 presents a Process Modeling and Solution Design course.

In MT4, A2 introduces a self-learning program, while A3 proposes a pedagogy with an integrated flipped classroom and Problem-Based Learning. Both methods aim to enhance understanding and practical application of BPM concepts, garnering positive feedback from students.

4.1.5 SRQ4: How Do Technologies Support BPM Education?

The teaching of BPM has undergone significant transformations driven by technological advancements. Among the 16 articles that directly address this research question, we identified four main technologies supporting the BPM teaching approach, as indicated in Table 7.

Table 7: Technologies that support BPM teaching.

Identifier	Technology	Citations	Total
TC1	Serious Games	A1, A5, A10, A12, A13, A14, A15, A16, A17	9
TC2	Business Process Modeling Software	A3, A4, A11	3
TC3	E-learning	A18	1
TC4	Frameworks	A8	1

In the case of Serious Games (TC1), A1 highlights the innovative use of gamified tools in BPM education for increased interest, motivation, and effective learning with real-time feedback.

A15 and A5 demonstrate the applicability and effectiveness of the INNOV8 game in BPM teaching, promoting intrinsic motivation, understanding of business processes, and student satisfaction.

Studies A12 and A13 explore the BPMN Wheel game as a learning tool, showing a positive impact on the learning flow and process modeling quality.

On the other hand, in Business Process Modeling Software (TC2) A3 proposes a pedagogical approach combining flipped classroom and Problem-Based Learning (PBL) to teach BPM, utilizing software such as Apromore, Bizagi, bpmn.io, Visual Paradigm, and Business Process Simulator.

A4 highlights the Horus Enterprise process modeling tool, which is recommended to support the Horus Method, enabling the modeling and simulation of business processes with support for various models.

A11 introduces the Model Judge framework, a platform for the automatic validation of process models, providing diagnostics on syntactic, pragmatic, and semantic quality issues, allowing instructors to create exercises and monitor students' progress in real-time.

About e-learning (TC3), A18 addresses situated learning through e-learning in the context of BPM, indicating a significant contribution of situated learning to understanding BPM logic. However, compared to face-to-face teaching, a lesser learning effect was observed in e-learning. The authors emphasize the importance of personal interaction and immediate feedback to understand BPM effectively.

A8 introduces the aCHAT-WF, a framework (TC4), an adaptive chatbot for workflows that is more user-friendly for learning than traditional interfaces. It connects students and teachers, separates content and conversation, adheres to the teaching approach, and delivers interconnected learning content through conversation. The tool allows the creation of different chatbots and tailored courses involving IT experts, conversation designers, and editors.

In summary, technologies like modeling tools, simulation games, e-learning platforms, and innovative frameworks such as aCHAT-WF have proven valuable in BPM education, providing practical experiences, continuous feedback, and a deeper understanding of business process concepts. These approaches represent an evolution in BPM education, incorporating innovative and interactive methods.

4.1.6 SRQ5: What Are the Main Challenges in the Training of BPM Professionals?

Few articles in the Systematic Mapping Study (SMS) address the alignment between university education in BPM and the technical requirements of the market, indicating a gap in this research area. Out of the three articles dealing with this issue, we identified three perspectives from professionals and employers regarding market demands and university education in BPM, as outlined in Table 8.

Table 8: Challenges in training BPM professionals.

Identifier	Challenge	Citations	Total
CH1	Increasing demand for professionals specialized in BPM	A16	1
CH2	Valuation of interpersonal skills by employers	A6	1
CH3	Excessive emphasis on technical skills in higher education institutions	A10	1

In light of this, considering the information in the articles, it becomes possible to extract an analysis aimed at understanding the perception of both BPM graduates and employers regarding BPM education to meet practical market demands.

In Increasing demand for professionals specialized in BPM (CH1), article 16 highlights the growing demand for Information Systems (IS) professionals with skills in business process analysis. The article suggests that modifying existing courses to incorporate analytics may effectively meet this emerging demand in the job market.

Furthermore, in the Valuation of Interpersonal Skills by employers (CH2), the study presented in A6 highlights the importance of interpersonal skills compared to technical skills in BPM. The results indicate that employers consider interpersonal skills more important than technical skills.

Lastly, in Excessive Emphasis on Technical Skills in Higher Education Institutions (CH3), article A10 highlights the growing demand for BPM knowledge in the industry and the need to incorporate this knowledge into university curricula.

It emphasizes the importance of innovative methods, such as serious simulation games, for situated training of BPM professionals, indicating gaps between the skills acquired in academic training and those required by the market, with a focus on interpersonal skills. Challenges include adapting teaching to meet digital demands.

4.2 RQ2: How Do Current BPM Educational Programs Align with the Curricular Guidelines Provided by the SBC and the BPM CBOK in Computing Courses?

For the comparison of the results of this SMS with the curriculum guidelines for BPM education, we initially relied on the training axes, competencies and content of the Training References for Undergraduate Computing Courses 2017, the most recent document provided by the Brazilian Computing Society (SBC). The training axes aim to empower the student with general competencies and encompass the main lines for the education of a Bachelor of Information Systems student. For the student to acquire these general competencies, it is necessary for them to develop derived competencies that require the mobilization of specific content taught in curricular units or courses.

The training axis for the management of information systems and information technology described in the document addresses general competencies that aim to develop skills such as "the management of information systems and information technology architecture in organizations, proposing solutions for information systems, software, and storage and communication infrastructure aligned with organizational goals and strategies, carrying out projects of information systems and information technology, and applying concepts, methods, techniques, and tools suitable for the management and governance of information systems and information technology." (Zorzo et al., 2017)

This training axis presents five derived competencies from these general competencies, classified according to the cognitive levels of the Bloom's Taxonomy scale (Create, Evaluate, and Analyze). Among these derived competencies, the first provides curriculum guidelines for content that should be considered in BPM education. Derived competence C.2.1 aims to develop the following skills: "Manage organizational processes, describing their operation, evaluating their performance, and implementing changes in their operation by applying concepts of information systems." (Zorzo et al., 2017)

The document describes the following content to be taught from this derived competencies: "Strategic planning, Organizational modeling, Business Process Management (Survey, Modeling, Analysis, Redesign, Automation, Evaluation, and Measurement), Automated tools for managing organizational processes, and Change management in organizational processes."

As highlighted in Table 9, we conducted a comparative analysis between the specific contents of derivative competency C.2.1 and the key topics mentioned in the articles qualified in our SMS. The aim of this comparison is to identify the extent to which the contents covered with students align with the curriculum guidelines established by the Brazilian Computing Society (SBC).

Table 9: Specific Content of SBC's Curriculum Guidelines x SMS Specific Research Questions.

Specific Content	SRQs
Strategic planning	SRQ1, SRQ2 and SRQ5
Organizational modeling	SRQ1, SRQ2 and SRQ4
Business Process Management	SRQ1, SRQ2, SRQ3, SRQ4 and SQR5
Automated tools for managing organizational processes	SRQ1, SRQ2 and SRQ4
Change management in organizational processes	SRQ2, SRQ4 and SRQ5

We can infer from this comparison that the main contents covered in BPM education are satisfactorily aligned with the specific content outlined in the curriculum guidelines of the SBC. Clearly, the specific content of Business Process Management is addressed in all specific research questions. In the results of SRQ1, we observe that specific contents such as strategic planning, organizational modeling, and automated tools for managing organizational processes are covered in CO5, CO2, and CO3, respectively.

The results of SRQ2 encompass all specific contents described in the curriculum guidelines of the SBC, by developing skills such as modeling, analysis, design, and implementation of business processes (SK1); working with BPM support tools (SK2); developing interdisciplinary skills (SK4); managing and closely observing organization processes (SK5 and SK6). Regarding SRQ4, technologies described in TC1, TC2, and TC3 address specific contents such as organizational modeling and automated tools for managing organizational processes, as well as change management in organizational processes by simulating the real context of BPM.

Additionally, we considered the Guide to the Common Body of Knowledge in Business Pro-

cess Management (BPM CBOK 4.0), the most recent document provided by the Association of Business Process Management Professionals International (ABPMP). This guide thoroughly describes the functional areas, purpose, functions, products, and modules of BPM education.

BPM CBOK 4.0 also presents an Essential BPM Curriculum from ABPMP in Appendix B, aiming to provide a proposal for educational courses to meet the growing need to develop in BPM professionals the "necessary and desirable skills to integrate business processes across different business functions and often distinct information technologies, delivering value to the customer" (CBOK 4.0, 2020).

The suggested course program consists of five mandatory BPM disciplines starting with a general introduction to BPM and continuing throughout the process lifecycle of modeling, analysis, design, and implementation. Complemented by three elective disciplines, allowing for a deeper exploration of BPM, culminating in a discipline on Business Process Strategy.

This program is presented in an organizational chart that divides mandatory and elective disciplines for BPM education, along with a curriculum model for undergraduate and postgraduate programs (Master's and MBA) in BPM. It provides detailed descriptions of objectives, student profiles, career opportunities, and an overview of the curriculum for each course, where the document details each discipline and the content to be covered. For our analysis, we will consider the mandatory disciplines mentioned for undergraduate courses teaching BPM, which are: "Introduction to BPM, Process Modeling, Design for Process Management, Implementation of Process Management and Business Process Strategy."

Table 10 demonstrates the comparative analysis between the mandatory disciplines of the essential undergraduate curriculum and the key topics mentioned in the articles qualified in our SMS. The goal of this comparison is to identify the extent to which the content and skills addressed by students align with the mandatory disciplines established by BPM CBOK 4.0.

Table 10: CBOK 4.0 Mandatory BPM Disciplines x SMS Specific Research Questions.

Mandatory BPM Disciplines	SRQs
Introduction to BPM	SRQ1, SRQ2 and SRQ4
Process Modeling	SRQ1, SRQ2, SQR3 and SRQ4
Design for Process Management	SRQ1, SRQ2 and SRQ4
Implementation of Process Management	SRQ1, SRQ2, SQR3 and SRQ4
Business Process Strategy	SRQ1 and SRQ2

This comparison leads us to conclude that the main contents covered in BPM education from the articles analyzed in the SMS are aligned with the mandatory disciplines suggested by CBOK 4.0. However, the contents are often grouped into a single discipline, reflecting on the available time to develop students' understanding and desired skills in each content area.

The contents and skills presented in SRQ1 and SRQ2 align with all the mandatory disciplines outlined by CBOK 4.0, as they cover everything from the introduction to BPM to the analysis, modeling, design, and implementation of process management. Additionally, in CO4 and CO5, SK4, SK5, and SK6 address business process strategy. The results of SRQ4 also demonstrate alignment with the mandatory disciplines, as the use of technologies such as serious games and process modeling software covers the contents of introduction to BPM, modeling, design, and implementation of process management.

4.3 Threats to Validity

Throughout this study, we identified some limitations and challenges in BPM education that deserve attention. The 10-year time constraint in the systematic literature review may lead to the exclusion of relevant studies predating this period, limiting the historical perspective of BPM education. The prevalence of European studies may introduce a geographical limitation in generalizing conclusions, not fully representing the global diversity in this field of education.

The specific choice of research sources, such as ACM DL, IEEEXplore, ScienceDirect, and Scopus, may introduce bias in the results, excluding other relevant sources. The criteria for article inclusion and exclusion, as well as quality assessment, are susceptible to subjectivity, influencing the final selection and results. Challenges include the complexity of assessing article quality, the diversity of sources and methods in the reviewed studies, and the need for curriculum adaptation to meet market demands.

Although the introduction of innovative methods, such as game simulations, is suggested as a solution to enhance practical understanding of BPM concepts, its implementation may face institutional resistance and practical challenges. In summary, the study highlights gaps between BPM education and market demands, emphasizing the importance of overcoming these challenges to improve education in the field in the future.

5 CONCLUSIONS AND FUTURE WORK

The teaching of BPM is undergoing a transformative phase, driven by technological advancements and increasing challenges. This study explored emerging trends, developed competencies, teaching and assessment methods, the impact of technologies, and the challenges inherent in aligning education with the job market.

We conclude that diversified approaches and the effective incorporation of innovative methodologies are crucial to meeting the dynamic demands of BPM education, preparing students to tackle real-world challenges with proficiency and adaptability.

We propose a research agenda to enhance BPM education. Firstly, we suggest investigating interpersonal competencies in the BPM context to integrate them into curricula. Secondly, we recommend periodic studies on the impact of emerging technologies on BPM education. Thirdly, we propose in-depth research on innovative methodologies, such as simulations and interactive games, to understand their impact on learning.

Additionally, we suggest comparative research between teaching approaches in different national contexts and the systematic evaluation of the alignment of BPM educational programs with real market demands. Lastly, the investigation of the development of dynamic BPM curricula to ensure continuous relevance amid changes in the business environment. This agenda seeks to enhance BPM education, effectively aligning it with the ever-changing demands of the business landscape.

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APPENDIX

Table 11: Selected papers.

ID	Title	Source
A1	Gamification of Business Process Modeling Notation education: an experience report.	ACM DL
A2	Application of Business Process Management in the Libyan International Medical University: History and Development.	IEEEXplore
A3	Teaching Business Process Management with a Flipped-Classroom and Problem-Based Learning Approach with the Use of Apromore and Other BPM Software in Graduate Information Systems Courses.	IEEEXplore
A4	Social BPM Lab – Characterization of a Collaborative Approach for Business Process Management Education.	IEEEXplore
A5	Learning Business Process Management through Serious Games: Feedbacks on the Usage of INNOV8.	IEEEXplore
A6	Uncovering the competency gap of students employed in business process analyst roles — An employer perspective.	IEEEXplore
A7	The Need for a Standardized and Common Way of Process Training.	Science Direct
A8	aCHAT-WF: Generating conversational agents for teaching business process models.	Scopus
A9	Managing Process Dynamics in a Digital World: Integrating Business Process Management and Routine Dynamics in IS Curricula.	Scopus
A10	Business process management and digital transformation in higher education.	Scopus
A11	Supporting the Process of Learning and Teaching Process Models.	Scopus
A12	BPMN wheel: A board game for business process modeling.	Scopus
A13	Gamification of business process modeling: A board game approach to knowledge acquisition and business process modeling with BPMN.	Scopus
A14	Business process management in the classroom.	Scopus
A15	Business process management and digital game-based learning.	Scopus
A16	Incorporating Analytics into a Business Process Modeling course.	Scopus
A17	Feedback on integrating a serious game in the Business Process Management learning.	Scopus
A18	How should we teach the logic of BPM? Comparing e-learning and face-to-face settings in situated learning.	Scopus
A19	Towards an understanding of real-time continuous feedback from simulation games.	Scopus
A20	Engaging students in a group role-play exercise to improve their understanding of business processes and ERP in an introductory information systems course.	Scopus
A21	Building 'holistic' business process modeling skills for IS graduates.	Scopus