

## Low-cost didactic materials in industrial production education

### Materiais didáticos de baixo custo no ensino da produção industrial

### Materiales didácticos de bajo costo en la enseñanza de la producción

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#### Abstract

This study aims to present an analysis of the use of low-cost didactic materials as support tools for practical teaching in Production Management and Production Engineering programs, considering their contribution to the effectiveness of active methodologies and experience-based learning. In a constantly evolving educational landscape, and given the need to align technical training with contemporary demands of the productive sector, the study discusses accessible alternatives that enhance student engagement, content retention, and the development of relevant technical and socio-emotional competencies. The methodological approach involved a literature review conducted in the Scopus and Capes databases, complemented by a basic bibliometric analysis aimed at understanding the scientific landscape on the subject. The results indicate a growing academic interest in pedagogical approaches that integrate theory and practice through accessible and easily implementable resources. The study concludes that low-cost didactic kits constitute viable tools for promoting more contextualized, inclusive, and effective learning, especially in public institutions that face budget constraints.

**Keywords:** Learning; Teaching; Active learning methodologies; Didactic materials.

#### Resumo

Este estudo tem como objetivo apresentar uma análise do uso de materiais didáticos de baixo custo como ferramentas de apoio ao ensino prático nos cursos de Gestão da Produção e Engenharia de Produção, considerando sua contribuição para a eficácia das metodologias ativas e da aprendizagem baseada na experiência. Em um cenário educacional em constante evolução e diante da necessidade de alinhar a formação técnica às demandas contemporâneas do setor produtivo, o estudo discute alternativas acessíveis que ampliam o engajamento dos estudantes, favorecem a retenção de conteúdo e promovem o desenvolvimento de competências técnicas e socioemocionais relevantes. A abordagem metodológica envolveu uma revisão de literatura realizada nas bases Scopus e Periódicos Capes, complementada por uma análise bibliométrica básica destinada à compreensão do panorama científico sobre o tema. Os resultados indicam um crescente interesse acadêmico por abordagens pedagógicas que integrem teoria e prática por meio de recursos acessíveis e de fácil implementação. O estudo conclui que materiais didáticos de baixo custo constituem ferramentas viáveis para promover uma aprendizagem mais contextualizada, inclusiva e eficaz, especialmente em instituições públicas que enfrentam restrições orçamentárias.

**Palavras-chave:** Aprendizagem; Ensino; Metodologias ativas; Materiais didáticos de baixo custo.

#### Resumen

Este estudio tiene como objetivo presentar un análisis del uso de materiales didácticos de bajo costo como herramientas de apoyo a la enseñanza práctica en los cursos de Gestión de la Producción y de Ingeniería de Producción, considerando su contribución a la eficacia de las metodologías activas y del aprendizaje basado en la experiencia. En un escenario educativo en constante evolución y ante la necesidad de alinear la formación técnica con las demandas contemporáneas del sector productivo, el estudio discute alternativas accesibles que fortalecen el

compromiso de los estudiantes, favorecen la retención de contenidos y promueven el desarrollo de competencias técnicas y socioemocionales relevantes. El enfoque metodológico incluyó una revisión de la literatura realizada en las bases Scopus y Periódicos Capes, complementada por un análisis bibliométrico básico destinado a comprender el panorama científico sobre el tema. Los resultados indican un creciente interés académico por enfoques pedagógicos que integran teoría y práctica mediante recursos accesibles y de fácil implementación. El estudio concluye que los materiales didácticos de bajo costo constituyen herramientas viables para promover un aprendizaje más contextualizado, inclusivo y eficaz, especialmente en instituciones públicas que enfrentan restricciones presupuestarias.

**Palabras clave:** Aprendizaje; Enseñanza; Metodologías activas; Materiales didácticos de bajo costo.

## 1. Introduction

Recent changes in student profiles, characterized by greater digital connectivity, dynamism, and a preference for visual stimuli, have intensified the demand for pedagogical approaches that move beyond traditional lecture-based instruction. In the context of technical and technological education, particularly in programs such as Industrial Production Management, the adoption of strategies that articulate theory and practice in an accessible, interactive, and meaningful manner has become essential. Within this scenario, practical activities developed with low-cost materials emerge as promising alternatives to enhance student engagement, support the understanding of complex concepts, and foster the development of competencies aligned with the demands of the productive sector.

Based on this issue, the present study proposes an analysis of the role of active learning methodologies and accessible didactic resources in the teaching-learning process. To this end, a literature review was conducted using the Scopus and Capes Periodicals databases, with the aim of mapping the scientific landscape on the topic, identifying good practices reported in the literature, and supporting the development of pedagogical proposals suited to contemporary needs in professional education.

Given an educational environment in constant transformation, marked by the accelerated incorporation of technologies, the continuous updating of labor market requirements and the heterogeneity of student profiles, rethinking teaching strategies becomes an urgent necessity. The use of low-cost materials in practical activities has the potential to democratize access to knowledge and provide more pedagogical experiences capable of stimulating critical thinking, fostering collaboration, and enhancing student autonomy.

By consolidating scientific evidence and systematizing experiences reported in the literature, this research contributes to the improvement of pedagogical practices adopted by educators, managers, and institutions. Moreover, it highlights the relevance of methodologies that take into account the actual infrastructure conditions and the sociocultural profile of students, particularly in the context of public education, pointing to viable pathways to make learning more contextualized, engaging, and effective. This study aims to present an analysis of the use of low-cost didactic materials as support tools for practical instruction in Production Management and Production Engineering programs, considering their contribution to the effectiveness of active learning methodologies and experience-based learning.

## 2. Methodology

A quantitative research study was conducted (Pereira et al., 2018), using simple descriptive statistics with absolute frequency values in quantities (Shitsuka et al., 2014) and, in a specific type of bibliometric literature review study. This study adopts a methodology that includes a literature review followed by a basic bibliometric analysis to understand the scientific landscape. To conduct the bibliographic survey, the study searched for scientific articles in the Scopus and Capes Periodicals databases. The method reviews scientific literature to construct the theoretical framework on the use of practical activities and low-cost kits as tools that support learning and knowledge development in Industrial Production Management programs. In addition to the literature review, the research performs a basic bibliometric analysis to outline the scientific context.

This method aims to establish the theoretical foundation of the topic and allows the study to identify good practices and relevant approaches discussed in the literature. The bibliographic survey also maps the main concepts and theories present in Industrial Production Management curricula to examine how active learning methodologies, particularly those based on low-cost materials, contribute to content assimilation and strengthen students' professional competencies.

Thus, the investigation examined the current scientific landscape by identifying the authors, institutions, keywords, and recurring themes that shape research on practical activities as support for theoretical instruction in technical and higher education. This mapping offers valuable insights for designing pedagogical approaches that are more accessible, interactive, and aligned with contemporary demands in production management education.

### 3. Results and Discussion

Research projects that examine the use of low-cost kits to enhance learning play a crucial role in expanding educational opportunities. Such initiatives can democratize access to instructional resources, allowing students from diverse socioeconomic backgrounds to engage in meaningful learning experiences under equitable conditions. Moreover, these projects foster innovation and creativity among both developers and users, contributing to a more inclusive and dynamic educational environment.

Regarding the scientific landscape related to the topic addressed in this study, a search conducted in the Scopus database for articles and reviews published between 2014 and 2024, in English, and whose titles included the keywords “teaching dynamics,” “simulation in production systems,” “experiential learning,” or “production management games,” resulted in a total of 1,524 documents. Table 1 presents the ten countries with the highest number of publications, with the United States standing out with 660.

**Table 1.** Number of publications.

Country	Values
United States	660
United Kingdom	125
Canada	115
Australia	95
India	70
South Africa	45
Malaysia	35
Taiwan	35
Indonesia	30
China	30

Source: Scopus Database (2024).

Table 2 shows the number of publications by knowledge area, with Social Sciences leading the results with 1,061 documents. This field encompasses the study of human behavior and social structures and contributes directly to discussions in education, economics, law, communication, and sociology. Its strong presence indicates that researchers frequently examine experiential learning and practical teaching resources through pedagogical, behavioral, and organizational lenses, highlighting the relevance of these approaches for understanding how students learn and interact in complex educational environments.

Business, Management, and Accounting (303), Medicine (229), and Engineering (131) appear next as prominent areas. These fields often rely on applied learning strategies and therefore benefit substantially from low-cost instructional tools and practice-based activities. The representation of Computer Science (127), Psychology (97), Arts and Humanities (92), Health Professions (92), Nursing (90), and Environmental Science (55) confirms that the topic extends across diverse domains,

illustrating its multidisciplinary character.

The distribution of publications shows that human and social sciences dominate the discussion, which suggests that researchers prioritize learning processes, instructional design, and human-centered approaches. However, the participation of engineering, health, and technological fields demonstrates a growing interest in integrating experiential methods into more technical and scientific curricula. The data also indicate that practical and low-cost educational resources resonate strongly in applied disciplines that seek scalable, accessible, and contextually relevant teaching solutions. This multidomain engagement underscores the versatility of these methodologies and reinforces their potential to contribute to more inclusive, interactive, and effective educational practices across higher education.

**Table 2.** Top Ten Research Areas.

#ID	Research Area	Number of Publications
1	Social Sciences	1,061
2	Business, Management and Accounting	303
3	Medicine	229
4	Engineering	131
5	Computer Science	127
6	Psychology	97
7	Arts and Humanities	92
8	Health Professions	92
9	Nursing	90
10	Environmental Science	55

Source: Scopus Database (2024).

The distribution of research areas also reveals considerable space for expanding studies and publications focused on management and engineering education. Although Business, Management and Accounting (303) and Engineering (131) appear among the most productive fields, their output remains proportionally small when compared to the breadth and complexity of these domains within higher education. This gap highlights an opportunity for researchers to deepen investigations on how low-cost materials, active learning strategies, and experiential approaches can strengthen professional training in production management, industrial processes, and related engineering areas. Expanding the scientific dialogue in these fields could foster more pedagogical frameworks, improve the alignment between academic training and industry demands, and promote teaching practices that are both accessible and technically rigorous.

The reviewed literature highlights the importance of low-cost instructional materials and experiential learning approaches for teaching Production Engineering and related fields. Becker and Park (2011) emphasize that accessible educational kits can enhance learning by enabling students to engage with concepts in concrete and meaningful ways. This approach aligns well with the needs of Management and Production Engineering programs, in which many abstract topics, such as production flows, variability, industrial layout, and operational decision-making, require practical mediation to ensure solid comprehension.

Several studies reinforce the idea that experiential learning narrows the gap between theory and practice. Fromm et al. (2021) and Jose et al. (2017) demonstrate that applied experiences allow students to internalize knowledge through direct experimentation, strengthening essential competencies for the productive environment. In this context, low-cost materials serve as effective tools for simulating industrial operations and organizational processes, fostering critical thinking and problem-solving skills. Simulations and educational technologies also emerge as central elements in the works of Garry (2019), Konak, Dillon and Smith (2014), Kwon et al. (2019), and Le et al. (2015), which underscore the role of interactive environments in increasing engagement and facilitating the understanding of complex concepts. Although many of these studies explore

advanced technological solutions, the underlying pedagogical principle based on modeling real processes through simplified representations remains fully compatible with low-cost materials. When well structured, these resources can reproduce phenomena in an accessible and replicable manner, offering sustainable alternatives for institutions facing budget constraints.

Studies such as Finch et al. (2015), Leal-Rodríguez et al. (2019), and Pulakos et al. (2015) show that practical activities directly promote the development of professional and socioemotional competencies. The literature indicates that experiential practices actively strengthen autonomy, communication, leadership, decision-making, and teamwork, all of which professionals need in dynamic industrial environments. When instructors use simple and affordable kits, they create opportunities for students to engage in real or simulated scenarios that require these competencies and prepare them for challenges similar to those they will face in professional settings.

The growing emphasis on active learning methodologies and innovative teaching strategies has transformed higher education, especially in programs that require hands on training. Studies such as those by Lau et al. (2024) and Roig et al. (2024) show that structured active learning environments and seminar based approaches strengthen departmental practices and increase student engagement in both introductory and advanced courses. Similarly, Silva et al. (2024) highlight the importance of active teaching learning methods in fostering student autonomy and deepening the learning process. In the same direction, Liqiu et al. (2024) demonstrate how well designed practical activities, supported by simulations and experimentation, contribute to applied course instruction and expand opportunities for experiential learning.

The integration of practical activities and problem-centered strategies further enhances the potential of these methodologies. Hagos and Lemma (2025) show that structured hands on approaches, combined with scaffolding, can significantly improve the understanding of complex content such as chemical kinetics within problem based frameworks. Likewise, Huang (2025) indicates that interactive instructional models promote more active and consistent learning behaviors. Rafael and Justino (2025) illustrate how flexible teaching platforms support the implementation of practical activities that strengthen the development of applied competencies. Together, these studies indicate that didactic innovation, supported by active methodologies and hands on experiences, plays a central role in improving engagement, comprehension, and professional readiness in higher education.

Researchers such as Huang et al. (2016) and Poore, Cullen and Schaaf (2014) demonstrate that active learning methodologies also support learning across diverse fields of knowledge, including environmental education and health. Their findings show that students benefit from experimentation-based strategies and those educators can apply the same principles to Production Engineering by adapting low-cost resources to different contents and instructional goals. Classical and contemporary studies on educational games and simulations, including Sauaia (1995) and Seaman, Brown and Quay (2017), indicate that practical activities stimulate critical reflection and promote deeper learning. By allowing students to experience simulated situations related to production and management, such resources contribute to knowledge consolidation and the development of strategic competencies.

Overall, the studies reviewed converge toward a significant conclusion: low-cost instructional materials serve as effective tools for promoting contextualized, active, and inclusive learning in the field of Production Engineering. Evidence from Becker and Park (2011), Fromm et al. (2021), Jose et al. (2017), Garry (2019), and others shows that practices grounded in experimentation increase student engagement, facilitate the understanding of complex content, and strengthen technical and professional training. These findings reinforce the potential of such resources to democratize education and support the development of essential competencies for contemporary productive systems.

## 4. Conclusion

The analysis conducted in this study highlights the significant potential of low cost didactic materials to enhance

teaching and learning processes in the fields of Production Management and Production Engineering. The reviewed literature demonstrates that these resources, when integrated with active learning methodologies and experiential strategies, increase student engagement, support the understanding of complex concepts, and strengthen essential technical and socioemotional competencies required in contemporary productive environments (Hagos & Lemma, 2025; Huang, 2025). The analysis conducted in this study highlights the significant potential of low cost didactic materials to enhance teaching and learning processes in the fields of Production Management and Production Engineering. The reviewed literature shows that these resources, when integrated with active learning methodologies and experiential strategies, increase student engagement, support the understanding of complex concepts, and strengthen essential technical and socioemotional competencies required in contemporary productive environments. These findings align with Becker and Park (2011), who emphasize the value of accessible kits for creating meaningful hands on learning experiences. They also resonate with Fromm et al. (2021), who emphasize how experiential learning helps bridge the gap between theory and practice in engineering education. In addition, they align with Silva et al. (2024), who demonstrates the value of low cost materials for supporting practical learning in Production Management. Finch et al. (2015), who show that experiential activities play an important role in developing employability and other key professional skills, further support these findings.

Overall, the studies reviewed consistently show that active learning methodologies and practical activities are essential for improving the quality of higher education. Research by Lau et al. (2024) and Roig et al. (2024) demonstrates that structured active environments increase engagement and strengthen instructional practices, while Silva et al. (2024) reinforces their role in promoting student autonomy. Likewise, Liqiu et al. (2024) and Hagos and Lemma (2025) confirm that practical, experience-based approaches enhance understanding of complex concepts, and Huang (2025) highlights the positive impact of interactive instruction on learning behaviors. As noted by Rafael and Justino (2025), flexible platforms further support the development of applied competencies. Collectively, these authors affirm that hands on learning and innovative teaching strategies play a central role in preparing students for contemporary professional demands.

The results also indicate a growing multidisciplinary interest in instructional strategies that integrate practical, accessible, and interactive resources, particularly within Social Sciences, Business, and Engineering. This reinforces the idea that low cost didactic materials constitute viable, inclusive, and effective tools for promoting contextualized learning that aligns with labor market demands. Such resources are especially relevant in public institutions facing budget constraints, where they help narrow the gap between theory and practice and contribute to preparing students for the challenges of modern production systems.

Despite its contributions, this study presents limitations related to the scope of the literature review and the absence of empirical validation in real classroom environments, which prevents a direct assessment of the impact of low cost materials on academic performance and competence development. Future research should expand the search scope and conduct empirical studies that evaluate, through instructional experimentation, the concrete effects of these materials on learning, engagement, and knowledge retention. Researchers should also conduct comparative analyses between low cost kits, digital simulations, and other educational technologies, such as those examined by Garry (2019) and Konak et al. (2014), to deepen the understanding of their distinct pedagogical impacts. Furthermore, the development and validation of new prototypes tailored to Production Engineering, accompanied by feasibility and applicability assessments, may contribute to broader adoption in diverse educational contexts. New studies can also deepen the understanding of how these resources fit into broader curricular innovation processes by examining instructor perceptions, institutional barriers, and scalability conditions.

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