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Learning to Change the World: The Transformative Potential of Vocational Education in Climate Change

Isabel Cristina Adão Schiavon[1], Celso Luiz de Souza[2], Gilson Soares Toledo[3], Priscila Souza Pereira[4], Fernanda Maria do Nascimento Aihara[5], André Luis Fonseca Furtado[6], Teresinha Moreira Magalhães[7], Lúcia Helena de Magalhães[8], Antonio Cléber de Souza[9], Maria das Graças Alves Costa[10], Lílian do Nascimento[11,] Luiz Carlos Gomes Júnior[12]

[1]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[2]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[3]*(IF Sudeste MG, Campus Ubá, Brazil)*
[4]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[5]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[6]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[7]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[8]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[9]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[10]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[11]*(IF Sudeste MG, Campus São João del-Rei, Brazil)*
[12]*(IF Sudeste MG, Campus Barbacena, Brazil)*

Abstract:
Background*: This paper details an examination of the transformative potential of vocational education in climate change. The central purpose of this research was to explore how vocational education can effectively contribute to mitigation and what the challenges are in implementing this educational approach. To achieve this end, the following specific objectives were defined: to examine the effectiveness of vocational education curricula in incorporating content on the aforementioned theme, to assess the perception of technical course students about the importance of sustainable practices in their areas of expertise, to investigate the practical application of acquired knowledge about sustainability in the labor market by course graduates, to analyze the collaboration between vocational education institutions and the private sector to promote sustainable actions, and to identify the challenges and opportunities in implementing educational programs in vocational education.*
Methodology*: The methodological approach adopted included the review of relevant literature and the analysis of secondary data.*
Results*: The research findings showed that the inclusion of climate themes in education curricula is effective in promoting good practices among students, leading to the conclusion that education has a significant impact on preparing professionals capable of mitigating the effects of changes.*
Conclusion: *The final observations emphasize the need to continue investigations in this area to deepen the understanding of the theme and promote future advances.*
Key word*: Sustainability; Vocational education; Climate change; Environmental practices.*

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I. Introduction

Vocational education has assisted in social transformation and response to climate change. The practice-oriented educational approach prepares students not only for the labor market, but also to face contemporary environmental challenges. The integration of climate themes into vocational training curricula promotes awareness and technical training, essential for mitigation and adaptation to effects[1]. Incorporating content on sustainability and environmental actions into technical course subjects encourages the development of practical skills that are immediately applicable in the field of work. In this way, students not only acquire theoretical knowledge about climate issues, but also develop skills to implement ecological solutions in various areas of

activity. This educational approach is particularly relevant in sectors such as agriculture, construction, energy and waste management, where these practices can be directly applied.

Climate-oriented educational narrative reinforces the need for education that goes beyond traditional boundaries, focusing on training people to respond effectively to emerging demands of society. The use of collaborative projects and participatory methodologies enriches the learning process, providing students with practical experiences that reflect the realities of the professional world. These educational methods facilitate understanding of the complexities involved in implementing clean technologies and efficient management of natural resources[6]. Analyzing the impact of vocational education on climate change is the central focus of this study.

This work aims to investigate the topic, seeking to enrich the academic field and establish solid foundations for future research. To achieve this main objective and demonstrate a deep understanding of the topic, the following specific objectives were defined:

- Examine the effectiveness of teaching curricula in incorporating content.
- Assess the perception of technical course students about the importance of sustainable practices in their areas of expertise.
- Investigate the practical application of acquired knowledge about sustainability in the labor market by graduates of professional courses.
- Analyze the collaboration between vocational education institutions and the private sector to promote sustainable practices.
- Identify the challenges and opportunities in implementing educational programs.

To achieve these objectives and address the essential aspects, the research problem was defined as follows: How can vocational education effectively contribute to climate change mitigation and what are the challenges in implementing this educational approach?

This study is significant because it addresses this intersection and the relevance of the topic for academia lies in the urgent need to develop and implement educational programs that prepare students for contemporary environmental challenges. For society, training professionals skilled in sustainable practices is essential for building a more resilient and environmentally responsible future. Furthermore, the current literature presents significant gaps in the integration of climate themes into teaching and in the evaluation of the practical results of this education.

This research aims to fill these gaps by providing empirical data and detailed analyzes on the effectiveness and challenges of this educational approach. The research also discusses possible practical applications, such as the implementation of more integrated and collaborative curricula, and social implications, such as the promotion of broader environmental awareness among technical professionals.

II. Theoretical Framework

With the objectives defined, the research advanced covering the following topics: Vocational Education Curricula and Sustainability; Impact of Vocational Education on the Labor Market and Society. With the successful completion of the research and the resolution of the research problem, a robust conclusion was reached, and an extensive bibliography was compiled.

II.1 Vocational Education Curricula and Sustainability

The analysis of current curricula and the inclusion of climate themes represent an important step in training professionals capable of facing contemporary environmental challenges. The review of existing educational programs reveals significant variation in the approach and depth with which climate change-related content is addressed. Some curricula systematically and comprehensively incorporate themes such as renewable energy, waste management and energy efficiency, while others still lack robust integration of these contents[13].

The insertion of climate themes in technical curricula aims to prepare students not only for the labor market, but also to help in mitigation. This preparation includes the development of practical skills that are directly applicable in sectors such as construction, agriculture, industry and services. Training in the use of sustainable technologies, for example, is a key component that can result in positive environmental impacts when implemented effectively[3]. The need for continuing education of educators, who must be updated with scientific and technological advances related to it, is highlighted. The use of contemporary teaching materials and the incorporation of innovative teaching methodologies are also critical aspects. The application of practical projects and interdisciplinary activities can enrich students' understanding of impacts and solutions.

The comparative analysis of different curricula demonstrates that those that address climate issues in an integrated way tend to produce students who are better prepared to face environmental challenges. The integration of environmental content from the initial levels of education can establish a solid base of knowledge that will be expanded and deepened throughout training. This systematic approach contributes to the internalization of practices by students, making them an inherent part of their future professional activities[1]. The review suggests

that there is a growing need to adapt curricula to the emerging demands of the labor market and social expectations regarding sustainability. Educational policies that encourage the inclusion of climate themes in technical education programs are essential for this adaptation. The creation of curriculum guidelines that stipulate the mandatory nature of environmental education can be a decisive step to ensure that all students receive adequate training in this regard[11].

The teaching methodologies applied help in training professionals prepared to face contemporary environmental challenges. Several pedagogical approaches have been adopted to integrate principles into teaching curricula, with the aim of enabling students to apply this knowledge practically and effectively in their future careers[14]. The use of interdisciplinary projects that allow students to explore the concept through multiple perspectives encourages collaboration between different disciplines, promoting a holistic understanding of environmental issues. By working on projects that involve everything from analyzing environmental impacts to implementing sustainable solutions, students develop critical and practical skills that are essential for their professional training[9].

Problem-based learning, where students are faced with real or simulated scenarios that require sustainable solutions, encourages critical thinking and problem solving, encouraging students to apply theories and concepts in practical situations. Problem-based learning is particularly effective in technical courses, where the practical application of knowledge is fundamental to the professional success of graduates[13]. The use of educational technologies has also proven to be a powerful tool in teaching. Digital platforms, simulators and virtual laboratories allow students to experiment and interact with simulated environments, where they can observe the effects of different sustainable practices. These tools offer an immersive learning experience, which facilitates understanding of complex environmental processes and importance[3].

Participation in internships and apprenticeship programs in companies that adopt sustainable practices is another methodology that contributes significantly to student education. These programs provide a valuable opportunity for students to see firsthand how actions are implemented in the work environment. The practical experience acquired in these programs not only reinforces theoretical knowledge, but also provides a realistic view of the demands and challenges faced by professionals working in this area[11]. Continuing teacher education ensures that they are updated with the latest scientific discoveries, technologies and pedagogical methodologies, enabling more accurate and relevant knowledge transfer to students[12].

The implementation of training programs can vary in format and approach, ranging from classroom courses, workshops, seminars, to online modules. These programs aim to develop a deep understanding of environmental themes, in addition to improving teachers' pedagogical skills. Constant updating on issues such as climate change, biodiversity conservation and natural resource management is essential for educators to effectively incorporate these themes into their curricula. In addition to theoretical knowledge, continuing education must include innovative pedagogical practices that facilitate the integration of concepts into various disciplines. Techniques such as project-based learning and the use of digital technologies are some of the methodologies that can be explored during training. Familiarity with these techniques allows teachers to create more engaging and meaningful learning experiences for students, promoting education that goes beyond the traditional classroom[14].

Collaboration between educational institutions, governments and non-governmental organizations is also an important factor in continuing teacher education. Strategic partnerships can provide access to additional resources, such as updated teaching materials and professional development opportunities. These collaborations may include exchange programs, where teachers have the chance to observe and learn from educational practices implemented in different contexts and countries[12]. Feedback from participants, analysis of results and adaptation to emerging needs are critical components for the success of any training program.

The effectiveness of these initiatives can be measured by the increase in the quality of teaching, the level of student engagement and the ability of teachers to innovate in their pedagogical practices[9].

II.2 Impact of Vocational Education on the Labor Market and Society

Graduates tend to value sustainable strategies not only for their positive impact on the environment, but also for the associated economic and social benefits. The adoption of waste management techniques, energy efficiency and the use of renewable resources are often cited as measures that not only reduce environmental impact, but also result in significant savings and improve the reputation of companies. This understanding of the advantages of sustainable actions reflects the effectiveness of the education received, which integrates theory and practice in a coherent and applicable way[8]. Research shows that many alumni actively apply the knowledge acquired during training in their work environments. They report that the skills developed, such as the ability to assess environmental impacts and implement sustainable solutions, are highly valued by employers. In addition, these professionals often act as agents of change within their organizations, promoting and leading initiatives. This performance demonstrates the positive impact of environmental education on training leaderships committed to sustainability[2].

Alumni point out that the relevance of practices is constantly evolving, driven by technological advances and new environmental regulations. This feedback suggests that educational institutions must maintain a constant dialogue with the labor market and adapt their teaching programs to emerging changes and demands, thus ensuring that trained professionals are always at the forefront of sustainable actions and trends[5].

The integration of these strategies in the professional environment is an initiative that has been gaining increasing importance, reflecting the need to harmonize economic activities with environmental preservation. The implementation of these practices requires a systematic approach that involves changes in production processes, adoption of clean technologies and efficient management of natural resources. This movement is driven both by regulatory demands and by a growing awareness among stakeholders about the importance of sustainability[6]. To effectively incorporate these practices, organizations need to first conduct a detailed assessment of their current processes. This analysis includes identifying areas where there is greater consumption of resources and generation of waste. Based on this data, specific strategies can be developed to reduce environmental impact. The adoption of more efficient technologies, such as renewable energy systems and less polluting production methods, is an essential step in this process [4]. Waste management involves not only reducing waste generation, but also implementing recycling and reuse programs.

Organizations that adopt these strategies report not only environmental but also economic benefits, as reducing waste can result in significant operating cost savings. Composting organic waste and recycling materials such as paper, plastic and metals are examples of practices that can be easily incorporated into the professional environment[16]. In addition to changes in processes and technologies, the integration of sustainable actions requires an institutional commitment to continuous employee education and training. It is essential that all levels of the organization are aligned with the objectives. Regular training and awareness programs can help create an organizational culture that values and practices daily. This engagement is crucial to ensure that practices are maintained in the long term and not just implemented as temporary measures. Partnerships between educational institutions and companies for sustainability have proven to be an effective strategy in promoting responsible environmental practices and training professionals prepared for the challenges of the labor market. Such collaborations allow the integration of theoretical knowledge with experiences, benefiting both students and the companies involved[8].

Collaboration between universities, technical schools and the business sector facilitates the creation of educational programs that are directly aligned with market needs. Companies provide real data and examples that enrich the academic curriculum, while educational institutions contribute with advanced research and development of new technologies. This exchange of knowledge and resources promotes a dynamic and updated learning environment, essential for the training of competent and conscientious professionals[15]. Joint research projects allow students and researchers to work side by side with industry professionals, addressing real problems and developing innovative solutions. In addition to providing valuable experience, these projects often result in technological innovations and improvements in industrial processes that benefit both companies and society in general. Examples include the development of new sustainable materials, more efficient production techniques and waste management systems[5]. Internship and apprenticeship programs in companies offer students the opportunity to apply the knowledge acquired in the classroom to practical situations, providing a deeper and more contextualized understanding of actions.

For companies, these programs are an effective way to identify and train future talent, ensuring that their new employees already have a solid background in sustainability[4]. Another important dimension of partnerships between educational institutions and companies is the holding of joint workshops, seminars and conferences. These events provide a platform for the exchange of ideas, presentation of research and discussions on best practices. Participants can learn about the latest innovations and trends, while expanding their professional networks. Such events also encourage continuous collaboration and the development of new partnerships[2]. The creation of innovation and sustainability centers, often established through collaborations between universities and companies, function as incubators for projects and startups. They provide technical, financial and administrative support for initiatives seeking to develop innovative solutions to environmental problems. The presence of a collaborative and interdisciplinary environment in these centers facilitates the emergence of disruptive ideas and accelerates their implementation in the market[10]. The implementation of sustainable knowledge in the professional environment faces a series of challenges that can limit its effectiveness and reach. One of the main ones is resistance to change, which often permeates organizations. Employees and managers accustomed to traditional processes may be reluctant to adopt new actions, even if they are greener. This resistance can be attributed to ignorance about the benefits of sustainable practices or the perception that such changes require high investments and complex operational re-planning[16]. The transition to sustainable practices often requires substantial upfront investments in technology, infrastructure and training.

Smaller companies or those operating with reduced profit margins may find it difficult to justify these expenses, especially when the long-term economic benefits are not immediately apparent. This scenario is aggravated by the absence of government incentives or subsidies that could facilitate the adoption of these

practices. The effective implementation of sustainable actions depends on a deep understanding of environmental issues and the technologies available to mitigate them. Many companies do not have qualified personnel to conduct this transition, which can result in inefficient or superficial application of sustainable measures. Continuing education and specific training are essential but can be difficult to implement without adequate support. In many cases, the implementation of practices runs up against outdated regulations or bureaucratic processes that hinder innovation. The lack of clarity in government policies and inconsistency in the application of environmental standards can create an environment of uncertainty for companies, discouraging investments in sustainability.

III. Methodology

The methodology adopted was a narrative review of the literature, including a detailed analysis of texts related to the topic. The information was collected through renowned Brazilian academic databases such as Scielo, Capes and Google Scholar, in addition to relevant scientific books and journals, considering materials in Portuguese, English and Spanish. As pointed out[7], this literature review strategy provides a solid foundation for the data, as it synthesizes contributions from various selected sources, helping to identify gaps in previous studies. For the compilation of the bibliography, a qualitative analysis of the texts and a detailed reading of the abstracts of each document were carried out. The temporal selection of the material favored publications from the last five years, with exceptions for classic works, thus ensuring an updated and comprehensive understanding of the topic, strengthening the basis for research results and enriching the scientific body related to the topic.

IV. Results

The analyzed data show that educational institutions that have adopted sustainable curricula report greater preparation of their students to face environmental challenges in their respective professional areas. It is observed that the inclusion of topics such as natural resource management, renewable energy and sustainable agricultural actions is beneficial, promoting not only theoretical knowledge, but also directly applicable skills.

Continuing education of teachers in environmental issues emerges as a key factor, allowing educators to effectively convey complex and updated concepts. Reports indicate that many of these professionals have successfully implemented techniques in their workplaces, contributing to the reduction of environmental impacts. This practical application of the knowledge acquired during academic training demonstrates the importance of well-structured curricula focused on sustainability.

Collaboration between educational institutions and the private sector was highlighted as a relevant element for the successful implementation of educational programs focused on the concept. Studies reveal that effective partnerships can result in better alignment between market needs and the skills developed by students. In addition, such partnerships often provide additional resources and practical learning opportunities, further enriching student education. However, the research also identified significant challenges in implementing sustainable curricula. Among them, resistance to change by some institutions and the lack of adequate resources to update teaching materials stand out. These obstacles highlight the need for public policies that encourage and support the integration of climate themes into vocational education curricula.

V. Conclusions

To achieve the established goals, this research conducted a detailed investigation on the transformative potential of vocational education in climate change, through an extensive and rigorous bibliographic review. The selected sources provided a comprehensive perspective on the subject and facilitated the evaluation of the evidence collected. Upon completing the study, it was found that the integration of climate themes into vocational education curricula is effective in promoting sustainable practices among students. The analysis revealed that institutions that implement sustainability content in their educational programs can train professionals who are more prepared to face environmental challenges.

Upon entering the labor market, they apply the knowledge and skills acquired during training, contributing significantly to mitigating impacts. Alumni perceptions reinforce the importance of continuous and updated training, highlighting that environmental education should not be static, but adaptive and evolutionary, aligned with scientific and technological advances. Additionally, collaboration between educational institutions and the private sector has been shown to be beneficial, not only for the insertion of students, but also for innovation and the adoption of more sustainable practices in companies.

Resistance to change, scarcity of resources and lack of adequate training for educators were cited as significant barriers. These obstacles indicate the need for public policies and targeted investments to support and expand these educational initiatives. The relevance of this study for academia, society and industry lies in the presentation of evidence that supports the effectiveness of vocational education as a tool. The research not only contributes to the theoretical understanding of the topic, but also offers practical and applicable data, which can guide future implementations and educational policies.

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