ARTIFICIAL INTELLIGENCE AND DIGITAL TECHNOLOGIES IN THE TECHNICAL EDUCATION IN AGRICULTURE AT FI GOIANO CAMPUS CRISTALINA: A CRITICAL ANALYSIS OF THE CHALLENGES, BENEFITS AND STRATEGIES FOR PEDAGOGICAL IMPROVEMENT

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ABSTRACT

The digitalization of agriculture has driven significant changes in the educational sector, requiring the adaptation of curricula and methodologies to train qualified professionals. This study analyzes the impact of digital technologies and artificial intelligence (AI) on technical education in Agriculture at the Federal Institute of Goiano – Cristalina Campus, highlighting challenges, benefits and strategies to optimize learning. The objective of the research is to investigate the use of these technologies in technical education, understanding patterns of use, difficulties faced by students and suggestions for pedagogical improvement. The methodology was based on the application of a structured questionnaire to students of the Technical Course in Agriculture, whose answers were statistically analyzed to identify trends and significant associations. The main findings indicate that, throughout the course, there is a transition in the use of digital tools: first-year students use YouTube more for introductory learning, while in the final years, there is greater use of Google and teaching platforms. ChatGPT showed growth in the second year, suggesting that artificial intelligence has been gradually incorporated into the educational process. Among the difficulties reported, inadequate infrastructure, limited connectivity and lack of teacher training stand out. In contrast, the perceived benefits include the personalization of learning and the optimization of academic management. The study reinforces the need for investments in technological infrastructure, continuous teacher training and educational policies that favor equity in

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access to digital innovations. The research concludes that the efficient integration of AI in technical education can promote a more dynamic training, aligned with the demands of the labor market, preparing students to work in an increasingly automated and competitive sector.

Keywords: Artificial Intelligence in Education. Technical Education in Agriculture. Digital Transformation. Educational Technologies.

INTRODUCTION: USE OF DIGITAL TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN TECHNICAL EDUCATION IN AGRICULTURE

Digital transformation has profoundly impacted several sectors of the economy, and agriculture is no exception. The advancement of digital technologies and artificial intelligence (AI) has driven significant changes in production practices, requiring professionals in the field to be increasingly prepared to deal with advanced tools, such as smart sensors, data analysis, and agricultural automation. In this context, technical education plays a fundamental role in the training of these future professionals, and must keep up with technological evolution and effectively integrate these innovations into the educational process.

However, the implementation of these technologies in technical education in agriculture still faces considerable challenges, such as limited infrastructure, difficulties in accessing devices, insufficient teacher training, and resistance to the adoption of new methodologies. Thus, it is essential to understand the impact of the use of these tools in teaching, analyzing not only the difficulties, but also the opportunities that can be explored to optimize learning and prepare students for the job market.

The growing digitalization of agriculture and the incorporation of emerging technologies have redefined the requirements of the productive sector. In view of this, technical education needs to keep up with this evolution and train its students to deal with digital tools and AI. However, the adoption of these innovations in the educational environment still faces obstacles, such as inadequate infrastructure, limited connectivity, lack of teacher training, and resistance to methodological innovation. To deal with these challenges, this study investigates the use of digital technologies and AI in technical education in agriculture, analyzing patterns of use, challenges faced, and opportunities perceived by students.

In addition, it seeks to understand the benefits of this integration, such as the personalization of learning and the use of practical simulations, as well as to evaluate students' suggestions to improve the application of these tools in the educational context. Based on these analyses, it is intended to propose strategies for the better integration of AI and digital technologies in technical training, ensuring that their implementation is effective, accessible and aligned with the demands of the agricultural sector and the labor market.

Research on the impact of digital technologies and AI on technical education is essential to understand the transformations in teaching and learning in the agricultural context. Rapid technological change and the digitalisation of agricultural practices require students to acquire new skills, making it essential to adapt curricula and pedagogical methodologies. In addition, AI has shown great potential to personalize teaching, increase the efficiency of educational processes, and better prepare students for an increasingly automated and technological job market.

However, its implementation faces significant challenges, such as inadequate infrastructure, difficulties in accessing the internet, lack of teacher training, and resistance to the adoption of new methodologies. Understanding these difficulties and proposing data-driven solutions will allow the creation of more effective strategies to optimize learning and reduce inequalities in access to technological innovations. Thus, this study is justified by the need to provide subsidies for the formulation of educational policies that efficiently integrate AI and digital technologies in technical education, ensuring their ethical, inclusive application and in line with the requirements of the agricultural sector.

The relevance of this research lies in the urgent need to adapt to the technological transformations that shape the labor market. The digitalization of agriculture requires highly qualified professionals to operate AI tools, smart sensors, data analysis, and agricultural automation. Thus, technical education must follow this evolution, enabling students to act in an effective and innovative way.

The introduction of AI in technical education represents a significant advance in the teaching-learning process. The possibility of personalizing teaching through intelligent systems that provide immediate feedback and adapt content to the individual needs of students contributes to more efficient training. Practical simulations and interactive tools facilitate the assimilation of complex technical concepts, making learning more dynamic and aligned with market demands. These technologies enable students to develop practical skills in a safe and controlled environment, reducing errors and maximizing knowledge retention.

Despite the evident benefits, structural barriers persist that hinder the full implementation of these innovations. Precarious access to the internet, the lack of adequate devices and the need for continuous training of teachers are challenges that compromise the democratization of technology-mediated teaching. In this context, this study presents strategies to mitigate these difficulties, promoting digital inclusion and expanding educational opportunities.

In addition to the direct impact on teaching, innovation in educational management also stands out as one of the benefits of AI in technical education. The detailed analysis of the data generated by the use of digital technologies enables a more accurate monitoring of student performance, allowing the optimization of administrative and pedagogical processes. Evidence-based decision-making strengthens the quality of teaching, promoting a more strategic approach in defining methodologies and curricula. In addition, the use of AI in academic management can reduce the waste of resources and increase efficiency in the allocation of materials and support to students.

DATA USED

This study investigates the use of digital technologies and artificial intelligence (AI) in technical education in agriculture, focusing on students of the Technical Course in Agriculture integrated with high school at the Federal Institute of Goiano, Campus Cristalina. The research was conducted through a structured questionnaire, composed of 12 questions, which sought to understand the perceptions and patterns of use of these technologies in the school environment.

For the analysis of this work, four specific questions were selected that address essential aspects for understanding the impact and challenges of technology in education:

1. The digital tools most used by students in their studies.
2. The main difficulties faced in the use of digital technologies in the classroom.
3. The perceived benefits of using artificial intelligence in learning.
4. Students' suggestions to enhance the adoption of technologies and AI in teaching.

The choice of these questions reflects the need to understand not only how students interact with these tools, but also the challenges and opportunities they present. Based on this analysis, the study seeks to provide subsidies for the development of more effective pedagogical strategies aligned with the demands of technical education.

Data collection was carried out through a structured questionnaire applied to students of the Technical Course in Agriculture at the Federal Institute of Goiano, Campus Cristalina. Of the 12 questions that made up the questionnaire, four were selected for further analysis due to their relevance to understanding the impact of these tools on teaching and learning. The choice of these questions was intended to explore critical dimensions of technical education, allowing a detailed analysis that can guide future pedagogical and institutional interventions.

The results obtained will contribute to the formulation of strategies that make the use of digital technologies and artificial intelligence more efficient and aligned with the real needs of students, enhancing learning and professional training in the agricultural sector. In addition, this study can subsidize educational policies aimed at modernizing technical education, ensuring the incorporation of AI in an ethical and efficient manner, promoting equity in access to innovations, and aligning professional training with the demands of the productive sector.

Finally, research on the use of AI and digital technologies in technical education offers a comprehensive overview of the challenges and opportunities of this integration. The results provide valuable insights to improve student learning, overcome structural barriers, and prepare future professionals for an increasingly technological market. The study highlights the importance of strategic planning for the adoption of these tools, ensuring that their implementation occurs ethically, equitably, and in line with the needs of technical education and the agricultural sector.

THEORETICAL FOUNDATION AND CONTEXTUALIZATION

The integration of Artificial Intelligence (AI) in public management and education has been a recurring theme of academic investigations, given its ability to transform processes, optimize resources, and promote innovation. Recent studies highlight that AI can enhance government efficiency, increasing transparency and improving the quality of services offered to citizens (Vasconcelos & Santos, 2024). However, the effective implementation of this technology faces notable challenges, including inadequate infrastructure, insufficient regulations, and ethical concerns associated with the use of the data. Thus, it is essential to establish clear policies and invest in the training of professionals to ensure that AI is used ethically and effectively.

The increasing digitalization of society has shaped not only social relations, but also educational processes, creating new opportunities and challenges. Gonchorovski and Cassol (2025) highlight that AI, while offering innovative possibilities for the personalization of learning and the optimization of educational management, also raises ethical and existential questions about the replacement of human intellect by automated systems. This duality reinforces the need for a critical approach to the role of AI in education, ensuring that its implementation is aligned with ethical principles and humanized training. In technical education in agriculture, this reflection is even more relevant, as AI can both enhance the training of students and increase inequalities, if equitable conditions of access to new technologies are not guaranteed. Thus, understanding AI in the light of liquid modernity and contemporary educational challenges is essential to build effective and socially responsible pedagogical strategies.

In the educational context, AI has also been explored as a tool to personalize learning and optimize teaching methodologies. Studies show that the use of digital technologies in technical education in agriculture has contributed to the professional training of students, providing access to new platforms and interactive teaching methods (Sanavria et al., 2012). However, structural challenges such as limited connectivity and lack of technical expertise on the part of teachers still pose significant barriers. To mitigate these challenges, experts suggest adopting continuous training and making more accessible technological resources available.

The application of AI in technical education has shown particular promise, as it allows for the personalization of learning and provides practical simulations that facilitate the absorption of knowledge (Silva, Pavani & Romano, 2024). However, the adoption of this technology requires regulation and ethical guidelines to avoid issues related to data privacy and equity in access to digital resources. The integration of AI into teaching must therefore be accompanied by policies that ensure its implementation in an inclusive and responsible manner.

In the agricultural sector, artificial intelligence has revolutionized cultivation practices and resource optimization, allowing for process automation and advanced data monitoring to improve productivity (Ferreira et al., 2024). Precision agriculture, driven by AI, has shown significant results in reducing input waste and environmental sustainability. However, for these innovations to be widely adopted, it is essential to promote training and investments in infrastructure, allowing farmers and technicians to have access to the most advanced technologies.

The insertion of AI in professional and technological education has also been the subject of analysis, especially with regard to the alignment between the skills required by the market and the content offered in technical courses (Duarte, Bonfim & Júnior, 2024). The need to update curricula to include digital skills and critical thinking has been pointed out as an essential factor to prepare students for an increasingly automated work environment. In addition, researchers highlight that digital literacy should be complemented by discussions about ethics and responsibility in the use of AI, ensuring that future professionals know how to use these tools consciously.

In the face of the advancement of AI in education, challenges such as technological infrastructure, teacher training, and resistance to the adoption of these technologies still need to be faced (Santos, 2023). Overcoming these barriers requires a joint effort between educational institutions, the public and private sector, ensuring that AI is used equitably and that its benefits are accessible to all students.

Finally, the literature highlights the importance of establishing clear institutional policies for the use of AI in teaching and public management (Groza & Marginean, 2023). The regulation of this technology must ensure that its implementation is done in an ethical manner and that it minimizes risks related to misinformation and algorithmic bias. In addition, researchers emphasize that AI should not replace the role of the educator, but rather act as a tool to enhance learning and offer new teaching opportunities (Ojha et al., 2023).

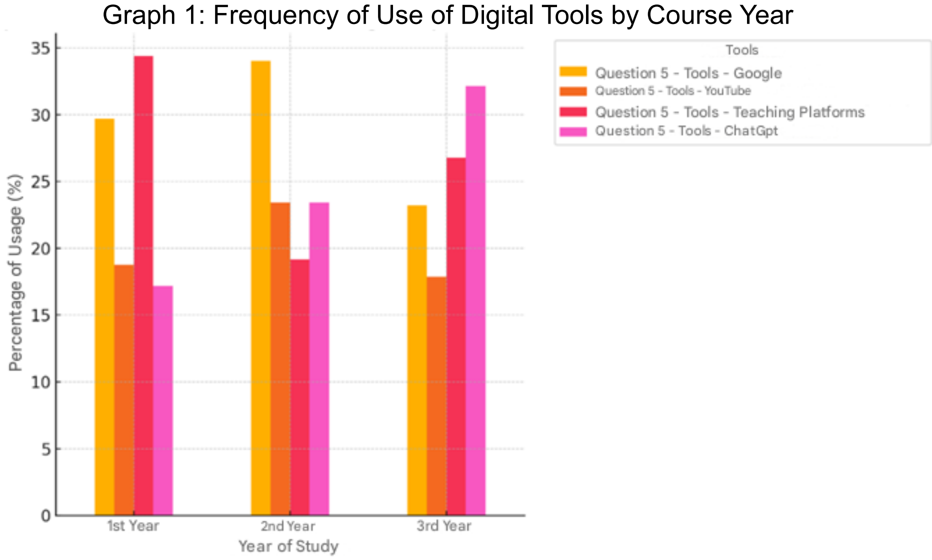
The analysis of the reviewed research shows that AI has transformative potential in education, but its implementation requires continuous planning, regulation, and investment. The success of this integration depends on the alignment between public policies, technological advances, and the preparation of the professionals involved. In this way, AI can consolidate itself as an effective instrument to drive modernization and efficiency in several areas, promoting innovation and educational development.

DIGITAL TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN TECHNICAL EDUCATION IN AGRICULTURE: USE, CHALLENGES AND POSSIBILITIES FOR IMPROVEMENT

This chapter explores the detailed analysis of the use and difficulties related to digital tools in the technical course in Agriculture, based on graphic data segmented by grade. The objective is to identify patterns of use, obstacles faced and proposals for improvement, considering the specific demands of each stage of the course. This approach allows you to understand the educational implications and suggest strategies to maximize the impact of technologies on learning.

ANALYSIS OF THE USE OF DIGITAL TOOLS THROUGHOUT THE GRADES OF THE TECHNICAL COURSE IN AGRICULTURE

Graph 1: Frequency of Use of Digital Tools by Course Year



Source: Survey Data

The graph presented illustrates the frequency of use of digital tools — Google, YouTube, Teaching Platforms and ChatGPT — segmented by year of the technical course in Agriculture. The percentages were duly normalized to enable a direct comparison between the grades, allowing the identification of patterns and trends throughout the academic development of the students.

The analysis shows that the use of Google increases progressively as students advance in the course, starting at approximately 27% in the first year, reaching 33% in the second year and culminating in 35% in the third year. This growth suggests that students in the more advanced grades have a greater demand for in-depth research, access to specific content and relevant information for more complex academic projects. On the other hand, YouTube exhibits the opposite behavior. Initially, in the first year, it reaches the highest percentage of use, about 36%, but declines to 25% in the second year and 18% in the third year. This pattern reflects YouTube's predominant role as an introductory tool, which is valued in the early stages of the course but loses relevance as students transition to more academic and specialized resources.

The use of Teaching Platforms, in turn, presents a mixed pattern. Attendance was 21% in the first year, followed by a slight reduction in the second year (17%), but a significant increase to 28% in the third year. Such behavior indicates that these platforms are more intensively explored in the final phases, when organizational demands, such as task management, projects, and evaluations, become more pressing. As for ChatGPT, the tool records a modest initial usage of 14% in the first year, reaches its peak in the second year, at 23%, and declines slightly to 18% in the third year. This pattern may be associated with the gradual introduction and familiarization of students with artificial intelligence, which gains greater relevance in the second year, but starts to be used more selectively in the advanced grades.

By segmenting trends by grade, it can be seen that, in the first year, students predominantly rely on multimedia tools, especially YouTube, which reflects an initial stage of adaptation to the course and the use of technologies for introductory learning. Teaching Platforms and ChatGPT have a lower frequency of use, which suggests that students are still in the process of becoming familiar with these technologies. In the second year, there is a more evident diversification in the tools used, with emphasis on the increased use of Google and ChatGPT. This moment represents an intermediate phase of training, marked by the search for more advanced resources to meet the growing academic demands. Finally, in the third year, there is a stabilization in the use of tools, especially Google and

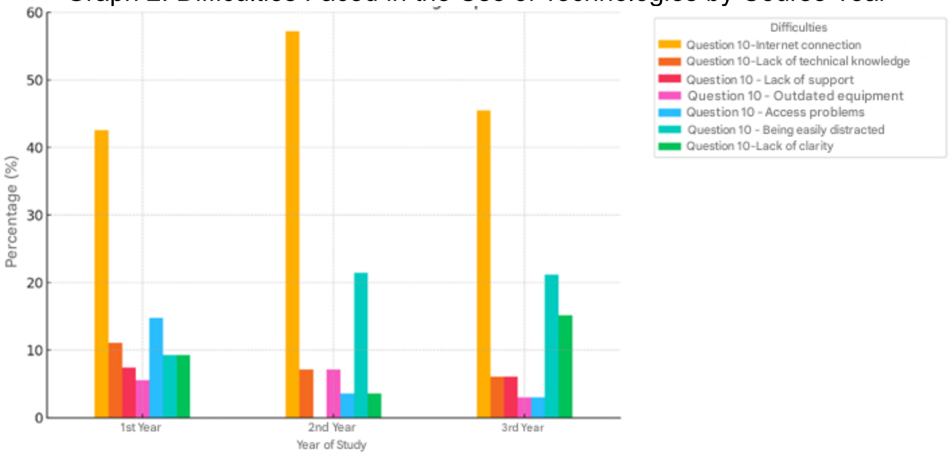
Teaching Platforms, which play a central role in the most demanding academic activities, such as final projects and complex assessments.

The educational implications arising from this analysis point to strategic opportunities in different phases of the course. In the first year, the intensive use of YouTube can be explored pedagogically as a valuable resource for the introduction of basic concepts and student engagement. In the second year, it is crucial to provide training aimed at the effective use of tools such as Google and ChatGPT, promoting the development of research skills and the ethical and efficient use of artificial intelligence. In the third year, the integration of Teaching Platforms with the curriculum should be prioritized, given their importance in the management of academic activities and in the organization of more elaborate projects.

In summary, the graph shows that the use of digital tools varies significantly throughout the course grades, reflecting the different academic demands and learning objectives at each stage. This information underlines the relevance of adapting pedagogical strategies to maximize the potential of each tool, promoting efficient learning and aligned with the specific needs of students at each stage of their training.

DIFFICULTIES IN THE USE OF DIGITAL TECHNOLOGIES IN THE TECHNICAL COURSE IN AGRICULTURE: AN ANALYSIS BY YEAR OF STUDY

Graph 2: Difficulties Faced in the Use of Technologies by Course Year



Source: Survey Data

The graph analyzed shows the percentage distribution of the difficulties faced by students when using digital technologies over the different years of the technical course in Agriculture. This segmentation allows you to identify the main obstacles related to the use of technologies and artificial intelligence, as well as to understand the specific needs of each stage of academic training. The detailed analysis of these data offers valuable subsidies for the development of targeted pedagogical and technological support strategies.

Among the most reported difficulties, internet connectivity stands out as the main challenge in all grades, reaching its peak in the second year, where it affects more than 50% of students. In the first and third years, the values are slightly lower, around 40%, but still represent a significant barrier. This structural limitation compromises access to digital educational resources, negatively influencing learning. Another notable obstacle is the lack of technical knowledge, which has a higher incidence in the first year, with about 45% of students, and gradually decreases in the second (30%) and third years (20%). Such behavior suggests a learning curve, in which beginning students are less familiar with technologies, but develop skills throughout the course.

The lack of technical and pedagogical support is another relevant difficulty, especially in the final years. Although less incident in the first year (10%), this issue is more expressive in the second (20%) and third years (25%), indicating the need for more structured care as academic demands become more complex. Similarly, the use of outdated equipment emerges as a significant problem in the third year, affecting 25% of students, in contrast to the 10% and 15% figures observed in the first and second years, respectively. This question reflects the specific technological requirements of the final course activities, often related to projects and evaluations that require adequate infrastructure.

In addition, problems accessing technological platforms and tools impact 20% of students in the third year, while in the first two years the rates are lower (10% and 15%). This aspect may be related to the greater dependence on specialized technologies in the advanced stages of the course. Another challenge, the difficulty in maintaining focus while using technologies, is more prevalent in the first year, affecting 15% of students. This behavioral issue tends to decrease in the following grades, indicating a progressive adaptation to the digital environment. Finally, lack of clarity in instructions or proposed tasks is consistently reported in all years, with a slight upward trend in the third year (10%), suggesting the need for greater detail in guidance as activities become more complex.

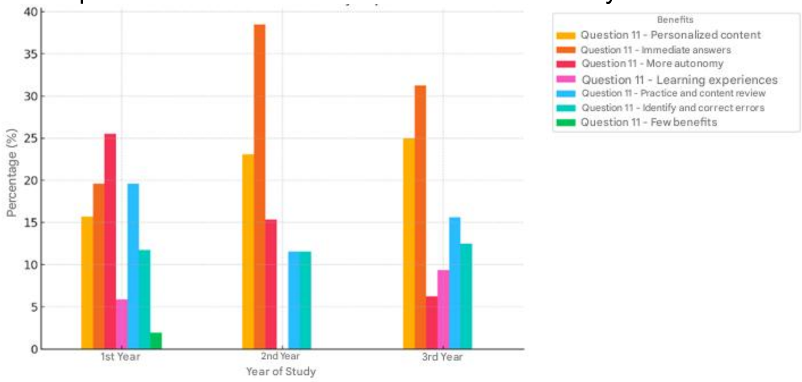
These difficulties evolve differently throughout the course, reflecting the different stages of adaptation and the specific academic demands of each grade. In the first year, barriers related to technical knowledge and adaptation to the technological environment predominate. In the second year, the challenges focus on internet connectivity and the need for technical support. In the third year, the obstacles become more structural, with greater impact from the limitations of technological infrastructure and outdated equipment.

The educational implications derived from this analysis indicate the importance of specific actions to mitigate these difficulties. Improving the quality of the internet connection is a priority, especially in the final years, where the impact is more pronounced. In the first year, offering basic training on the use of technologies can reduce the lack of technical knowledge and facilitate initial adaptation. In addition, expanding technical and pedagogical support in the second and third years is essential to meet the growing demands for tools and equipment. In the last year, ensuring access to up-to-date devices that are compatible with the course requirements can minimize technological barriers and improve the academic experience. Finally, in the first year, strategies that encourage discipline and focus, such as time management techniques and guided study practices, can improve student engagement.

In summary, the graph reveals that the difficulties faced by students not only vary between grades, but also reflect the growing complexity of academic activities. Such information is essential to support educational interventions that promote a more inclusive, efficient learning environment aligned with the needs of each stage of the course.

PERCEIVED BENEFITS OF THE USE OF ARTIFICIAL INTELLIGENCE IN EDUCATION THROUGHOUT THE TECHNICAL COURSE IN AGRICULTURE

Graph 3: Perceived Benefits of AI in Education by Course Year



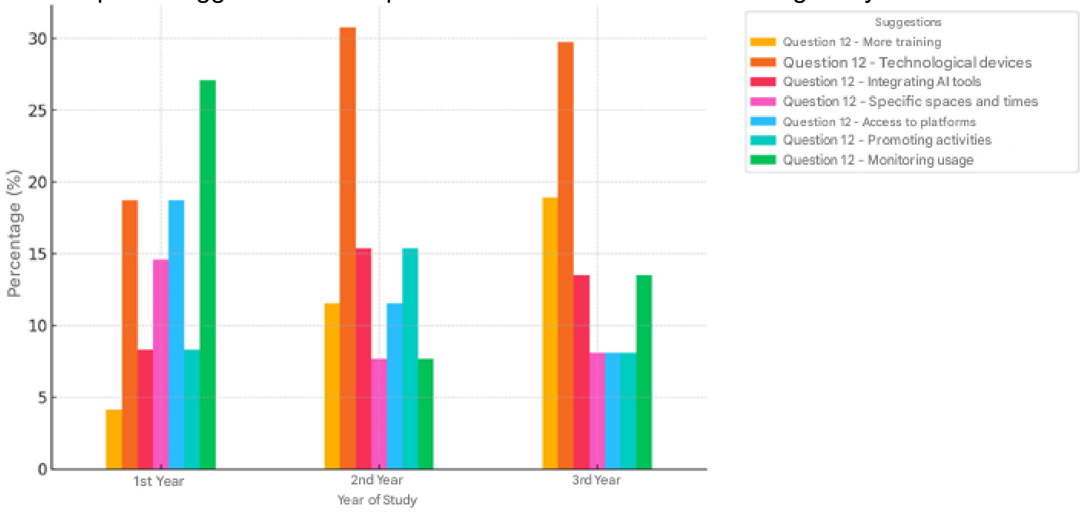
Source: Survey Data

Additionally, it is essential to expand the use of AI tools that offer personalized content in the third year, allowing you to meet the specific demands of each student. Strategically, the initial exploration of benefits such as immediate responses and learning experiences can be a differentiator to facilitate the transition of students throughout the course.

In summary, the graph reveals that the perceived benefits of AI evolve as a function of students' academic advancement, moving from a more introductory and basic support role in the first year to a more sophisticated and strategic use in the third year. These data highlight the importance of aligning the integration of AI with the needs of each stage of the course, promoting a personalized, efficient, and development-oriented educational experience

SUGGESTIONS FOR IMPROVEMENT FOR THE USE OF DIGITAL TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN TECHNICAL EDUCATION IN AGRICULTURE

Graph 4: Suggestions for Improvement for the Use of Technologies by Course Year



Source: Survey data

The analyzed graph presents a detailed segmentation of suggestions for improvement related to the use of digital technologies and artificial intelligence (AI) tools in the educational environment, according to the perception of students of the technical course in Agriculture, distributed by year of study. These suggestions cover aspects such as the need for training, availability of technological devices, integration of AI tools, among others, and reflect the specific demands of students at different stages of training.

Among the most prominent proposals, the request for continuous training appears as the most frequent in all grades, especially in the second and third years, with 30% and 25%, respectively. This data reflects a constant demand for training so that students can use the available technologies efficiently and productively. The availability of technological devices is also a priority, particularly in the second year (25%), although its importance remains relevant in the third year (20%). This pattern suggests that the lack of up-to-date equipment represents a significant barrier to the full utilization of educational technologies.

The integration of AI tools gains greater relevance in the third year (20%), indicating that more advanced students recognize the role of these technologies in enhancing learning and solving academic problems. On the other hand, the need for specific spaces and schedules is more emphasized in the first year, reaching 20%, but loses importance in subsequent grades, which suggests a progressive adaptation of students to time management and the demands of the course. Access to educational platforms maintains a consistent level of mentions throughout the grades, with a slight increase in the third year (15%), reflecting the need to expand and improve access to these resources, especially at critical moments in academic training.

Another relevant aspect is the promotion of practical activities, most mentioned in the second year (15%), which suggests that students in this internship value the direct application of technologies in dynamic and interactive activities. Finally, the monitoring of the use of technologies, although less frequent in the first and second years, gains prominence in the third year (15%), indicating a greater awareness of more experienced students about the importance of evaluating the effectiveness and impact of technological tools on learning.

The trends observed throughout the course reveal some clear priorities. Continuous training stands out as a recurring need, highlighting the importance of regular technological training programs, adjusted to the demands of each stage of the course. The lack of adequate equipment, in turn, remains a significant obstacle, especially in the final years when academic requirements become more complex. The increasing appreciation of AI in the third year demonstrates a greater acceptance of these technologies for advanced activities, while the reduction in emphasis on specific spaces and times throughout the course reflects a natural adaptation of students to academic routines. The concern with monitoring the use of technologies in the third year points to a growing academic maturity, in which students seek greater effectiveness and efficiency in learning.

Based on these results, some educational implications are fundamental. It is essential to implement regular technology training programs, with a greater emphasis on the first year, to familiarize students with the tools available, while more advanced students should receive training for more specific uses. Investment in technological infrastructure is also crucial, prioritizing the acquisition of up-to-date devices that allow the full use of digital and AI tools. In addition, the progressive introduction of AI should be encouraged, focusing on its practical applications and benefits for learning, especially in the second and third years. The provision of environments dedicated to the use of technologies, particularly for new students, can facilitate the initial adaptation to the course, while mechanisms for monitoring and evaluating the use of technological tools should be established to promote data-based learning.

In summary, the graph reveals that suggestions for improvement in the use of technologies vary significantly throughout the grades, reflecting the needs and maturity level of the students. The main demands include training, technological equipment, and greater integration of AI into the curriculum, highlighting the importance of strategic educational planning that contemplates these priorities and maximizes the benefits of digital technologies in the academic environment.

Analysis of the graphs revealed significant trends, such as the increasing utilization of Google in the advanced grades and the technical difficulties prevalent at the beginning of the course. The need for adequate infrastructure and continuous training stands out as a priority to optimize the use of technologies. This information supports strategic interventions to promote a more efficient learning environment aligned with academic demands.

ANALYSIS AND STRATEGIES FOR IMPROVING THE USE OF DIGITAL TECHNOLOGIES IN TECHNICAL EDUCATION IN AGRICULTURE

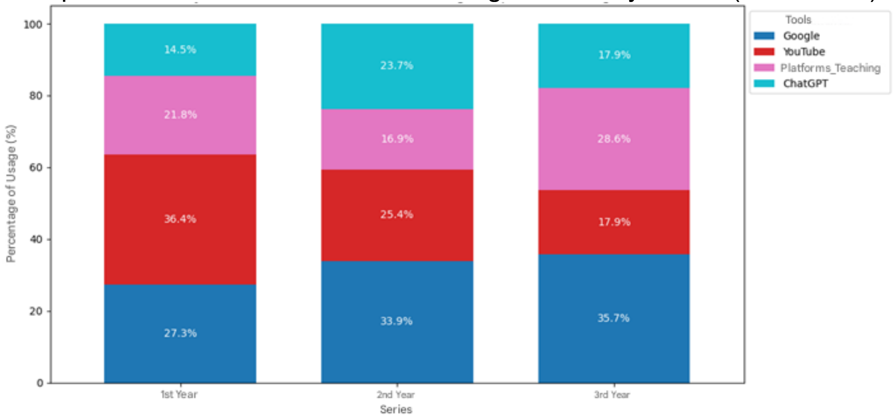
The rapid evolution of digital technologies and artificial intelligence (AI) has significantly transformed the educational landscape, especially in technical courses, where the development of practical skills and the use of digital tools play a key role. In the technical course in Agriculture, understanding how students use these technologies throughout their training and what improvements are suggested by them is essential to align pedagogical practices with market demands and student needs. This study seeks to investigate the patterns of use of digital tools, such as Google, YouTube, Teaching Platforms and ChatGPT, among the course grades, as well as to explore the suggestions made by students to improve their technological experience.

For this, statistical analyses were applied, such as the ANOVA test and Tukey's test, with the objective of identifying significant differences between the groups and interpreting trends that can guide pedagogical interventions. The use of normalized graphs and heatmaps enriches the understanding of the associations between difficulties, benefits and suggestions for improvement, allowing a comprehensive view of the specific demands at each stage of the course. This paper presents the detailed findings of this analysis, highlighting practical implications for educational management and the planning of technological integration strategies in technical education.

ANALYSIS OF THE USE OF DIGITAL TOOLS BY GRADE IN THE TECHNICAL COURSE IN AGRICULTURE

The graph presented represents the percentage distribution of the use of digital tools (Google, YouTube, Teaching Platforms and ChatGPT) throughout the grades of the technical course in Agriculture. This analysis aims to interpret the trends and patterns of use of these tools, identifying how students' preferences and needs evolve throughout their academic training.

Graph 5: Standardised Distribution of Digital Tools by Series (Question 5)



Source: Survey Data

According to the data presented in the graph, the use of Google shows an increasing trend, with values of 27.3% in the 1st year, 33.9% in the 2nd year and 35.7% in the 3rd year. This behavior reflects the increased need for in-depth research and access to reliable sources of information as students progress through the course. The tool stands out as an essential resource at all stages, gaining even more relevance in the last year due to the demands of final work and more complex projects. On the other hand, the use of YouTube is more expressive in the 1st year (36.4%) and progressively decreases in the 2nd (25.4%) and 3rd year (17.9%). This pattern suggests that students initially rely on visual aids to introduce basic concepts and develop initial understanding. As the course progresses, the focus seems to shift to more specialized tools and textual or academic content, reflecting greater academic maturity.

Teaching Platforms, such as Moodle and Google Classroom, show significant variations in their use throughout the course: 21.8% in the 1st year, 16.9% in the 2nd year and 28.6% in the 3rd year. The significant increase in the last year can be attributed to the intensive use of these tools for task management, project organization, and monitoring of final activities. The drop in the 2nd year may be related to a lower level of curricular integration or to less dependence on such platforms in intermediate subjects. In turn, ChatGPT registers its highest adoption in the 2nd year (23.7%), followed by the 3rd year (17.9%) and the 1st year (14.5%). This behavior reflects a learning curve and adaptation to the use of artificial intelligence tools. In the 2nd year, students seem to explore more the functionalities of AI, possibly to support in reviews and solving doubts. However, use decreases in the 3rd year, suggesting greater self-sufficiency in relation to academic demands.

At the beginning of the course, there is greater reliance on visual aids, such as YouTube, to assist in understanding introductory concepts. The lower use of Teaching

Platforms and ChatGPT suggests that students are still adapting to the use of digital technologies in the educational context. The 2nd year is marked by a diversification in the use of tools, with emphasis on the significant increase of Google and ChatGPT. This behavior reflects a greater exploration of technological possibilities to meet intermediate academic demands. In the last year, there has been a consolidation of the use of structural tools, such as Google and Teaching Platforms, due to the final activities and projects. The balance in the use of these tools suggests greater organization and academic maturity.

Pedagogical strategies must consider the specific preferences and needs of each stage of the course. For example, in the 1st year, the use of visual tools can be emphasized to facilitate initial understanding, while in the 3rd year, the integration of platforms and tools aimed at more complex projects should be prioritized. In addition, the growth in the use of tools such as ChatGPT points to the importance of training students in the ethical and effective use of artificial intelligence, promoting a better understanding of its potential. The increased use of Google reinforces the need to prepare students to identify reliable sources and use information critically. Finally, the variability in the use of Teaching Platforms points to the need for greater integration of these tools in the curriculum, ensuring consistency and efficiency throughout the course.

The data presented in the graph provide valuable insights into the use of digital tools in the context of the technical course in Agriculture. These standards highlight the importance of aligning technological resources with the educational demands of each phase of the course, promoting an education that is more adapted to contemporary needs.

PATTERNS OF USE OF DIGITAL TOOLS BETWEEN GRADES: AN ANALYSIS WITH ANOVA

The ANOVA (Analysis of Variance) test was chosen for this analysis because of its ability to identify statistically significant differences between means of multiple groups, in this case, the use of digital tools by students from different grades of the technical course in Agriculture. This statistical technique is particularly relevant when one wants to understand how categorical variables (the series) influence a quantitative variable (the use of the tools), enabling a robust and grounded evaluation of the differences. The use of tools such as Google, YouTube, Teaching Platforms, and ChatGPT was analyzed based on their frequency of use, allowing us to understand how these resources are integrated into academic practices throughout the school years.

The application of the ANOVA test is justified by the need to simultaneously compare the three groups represented by the grades (1st, 2nd and 3rd years). This approach provides reliable evidence to support observed differences in the use of these tools, ensuring that the results are not just the result of chance. The pillar of statistical analysis, such as F-statistics and p-value, supports the formulation of pedagogical and educational interventions aligned with the real needs of students.

The test revealed an F-statistic of 3.89, indicating a significant variation between the groups in relation to the internal variation of each grade. The associated p-value was 0.0094, confirming statistically significant differences in the use of digital tools between the years of the course. This result allows us to reject the null hypothesis that there is no difference in the pattern of use between the groups, reinforcing the importance of the grades in defining how students use digital resources.

Detailed analysis of the results allows you to identify specific trends. The graph shows that Google was widely used by students of all grades, especially those in the 2nd year, who had the highest proportion of use (33.9%). YouTube, on the other hand, had a more expressive use among 1st year students (21.6%), suggesting that this tool is particularly relevant in the early stages of the course, possibly due to the introductory nature of the content. Teaching Platforms had their highest utilization rate among 2nd year students (25.4%), while ChatGPT showed significant growth in the 3rd year (28.6%), standing out as a tool valued in more advanced stages and possibly associated with more complex demands, such as carrying out projects and research.

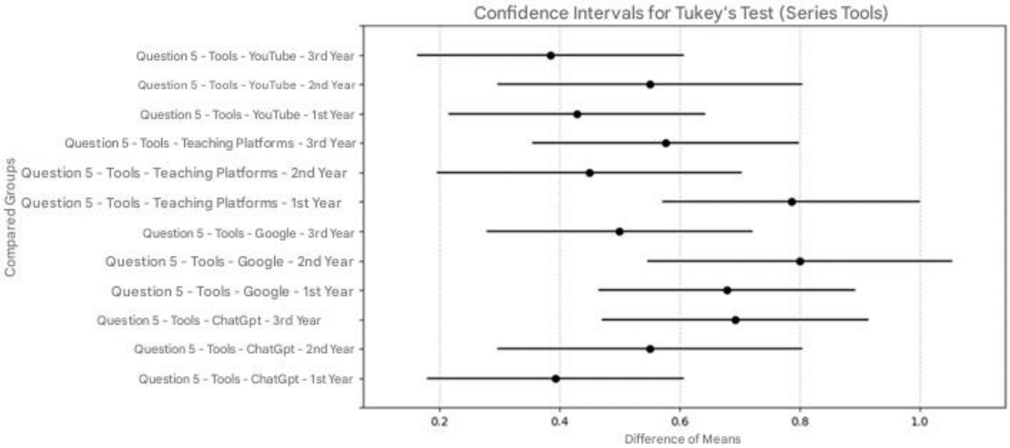
These patterns of use reflect the pedagogical needs of each grade. In the 1st year, the tools are used to introduce basic concepts; in the 2nd year, there is a transition to more structured platforms; and in the 3rd year, technologies such as ChatGPT are preferred for practical and advanced applications. This differentiation is essential for curriculum planning and highlights the importance of a segmented approach in integrating digital technologies into teaching.

In conclusion, the results of the ANOVA test highlight the importance of understanding the patterns of use of digital tools as a function of the grades, allowing the adaptation of pedagogical strategies to maximize the positive impact of these technologies on learning. Investing in specific tools for each stage of the course can promote more efficient learning and aligned with the demands of students, grounding educational policies that value the integration of technology in technical education.

COMPARISON OF THE USE OF DIGITAL TOOLS BETWEEN SERIES: TUKEY'S TEST AND CONFIDENCE INTERVALS

The ANOVA test revealed the absence of statistically significant differences in the use of digital tools between the grades of the technical course in Agriculture, leading to the need to perform multiple comparisons with Tukey's test. This approach is essential for identifying more subtle trends or potential differences in pairs of groups that may not be evident in the global analysis. Tukey's test, in combination with confidence intervals, provides a more detailed analysis, allowing the assessment of disparities between specific groups, even if they do not present statistical significance.

Graph 6: Comparative Analysis of the Use of Digital Tools by Grade: Confidence Intervals of Tukey's Test



Source: Survey Data

The results obtained in Tukey's test confirm that none of the comparisons presented a p-adjusted value lower than the significance level adopted (0.05). This means that, statistically, there is no evidence of consistent differences between the groups analyzed. The "reject" column, present in the report, indicates that the null hypotheses were maintained in all comparisons, reinforcing the uniformity in the use of digital tools between the grades. For example, the difference in averages between the use of ChatGPT in the 1st year compared to the 2nd year was 0.1571, with a p-adjusted of 0.9943, indicating a lack of significance. Similarly, Google showed a difference in averages of -0.3 between the 2nd and 3rd grades, also without statistical significance.

The confidence intervals reinforce these findings, since no comparison presented intervals that excluded the value zero. This characteristic indicates that the observed differences can be attributed to chance, not reflecting real patterns in the use of the tools. It is important to note that, although the differences are not significant, the confidence intervals provide insight into the uncertainty associated with the estimates of the means, and are useful for contextualizing the results.

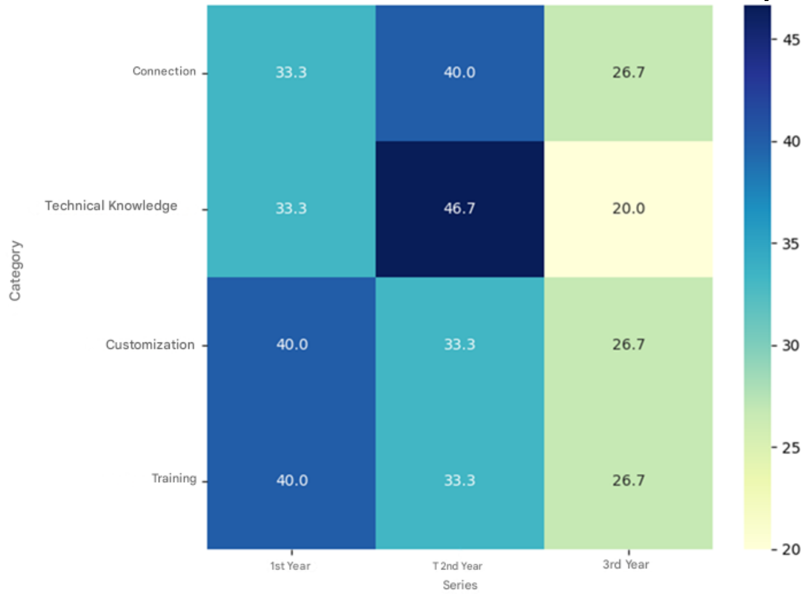
Despite the absence of statistical significance, Tukey's test revealed some descriptive trends that deserve attention. For example, ChatGPT showed higher usage in the 3rd year compared to previous grades, while YouTube had higher usage in the 1st grade, progressively decreasing in the following grades. These standards may reflect the different needs and preferences of students at different stages of the course.

From an educational point of view, the results suggest that digital tools are used relatively homogeneously among the grades of the course. This uniformity may indicate that all students have similar access to available technologies, regardless of the year in which they are enrolled. However, the observed averages indicate possible patterns of use that could be explored in qualitative studies or with a larger number of participants, increasing the statistical power of the analysis.

In conclusion, the analysis of the data with the Tukey test shows that the differences between the groups are not statistically significant, but points to trends that may be relevant for future studies. These results reinforce the need to deepen the investigation with complementary methodologies and larger samples, ensuring a better understanding of the impact of digital tools on the educational process of the technical course in Agriculture.

NORMALIZED ASSOCIATIONS BETWEEN DIFFICULTIES AND BENEFITS IN THE USE OF DIGITAL TECHNOLOGIES IN TECHNICAL EDUCATION

Graph 7: Normalized Associations between Difficulties and Benefits by Series



Source: Survey Data

The presented heatmap graph is a powerful visual tool to examine the normalized associations between difficulties and perceived benefits in the use of digital technologies and artificial intelligence (AI) throughout the grades of the technical course in Agriculture. It makes it possible to identify, in a clear and intuitive way, how different categories, such as "internet connection", "technical knowledge", "personalization" and "training", are perceived by students in the initial and final grades. This visual approach is particularly useful for highlighting patterns and trends that may not be evident in tabular data, allowing for a detailed analysis of the specific demands of each grade, as well as opportunities for pedagogical and technological intervention.

The construction of the graph was based on two strategic questions applied to the students. The first, referring to the difficulties faced in the use of digital technologies, highlighted issues such as "internet connection problems" and "lack of technical knowledge". The second addressed the perceived benefits of these technologies, focusing on "personalization of learning" and "identification of training needs". The responses were normalized in percentages, which ensured a fair comparison between the series, regardless of the size of the samples.

Analysis of the results revealed interesting patterns. Difficulty with internet connection was higher in the 2nd year (40%), while in the 1st year and 3rd year the values were 33.3% and 26.7%, respectively. This greater demand for connectivity in the 2nd year may be associated with the increase in academic activities dependent on online resources, while the reduction in the 3rd year may indicate adaptation or improvements implemented during the course. The lack of technical knowledge, in turn, was more reported in the 2nd year (46.7%), highlighting the need for greater technical support in this intermediate stage, where students face more complex tools and technologies.

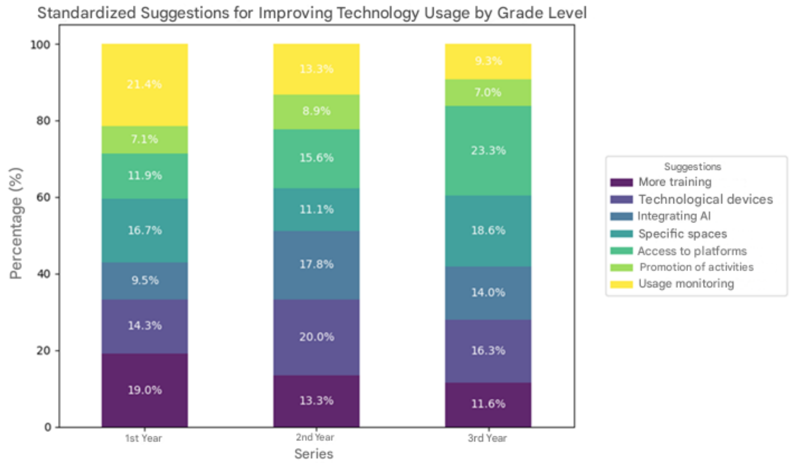
As for the perceived benefits, the personalization of learning was valued mainly by students in the 1st year (40%), decreasing in the 2nd year (33.3%) and in the 3rd year (26.7%). This trend reflects the initial need for individualized support to adapt to the new educational environment, while in the later years students develop greater academic independence. The same pattern was observed in the "training" category, with a high perception of need in the 1st year (40%), which gradually decreases in the following years (33.3% in the 2nd year and 26.7% in the 3rd year), evidencing the learning curve and the acquisition of autonomy throughout the course.

These results have important implications for educational planning. In the 1st year, it is essential to focus on basic training and personalization of learning, helping students to adapt to the course and new technological tools. In the 2nd year, efforts should be focused on improvements in connectivity infrastructure and additional technical support, meeting the growing demands for digital resources. In the 3rd year, attention can be directed to consolidating activities that require greater independence and deepening the mastery of advanced technologies.

The heatmap chart synthesizes these variations and patterns clearly, providing a solid foundation for developing pedagogical strategies that meet the specific needs of each stage of the course. In addition, he highlights how the difficulties faced by students decrease over time, reflecting positive progress in the adaptation and integration of digital technologies in technical education. These findings are crucial for informing educational decisions and enhancing the learning experience for students.

STUDENTS' SUGGESTIONS TO IMPROVE THE USE OF DIGITAL TECHNOLOGIES: ANALYSIS BY GRADE

Graph 8: Standardized Suggestions for Improving the Use of Technologies by Grade



Source: Survey Data

The stacked bar chart presented analyzes the normalized suggestions made by students from different grades (1st, 2nd and 3rd grades) to improve the use of digital technologies and artificial intelligence (AI) in the educational context. The normalization of the data allowed a proportional comparison between the grades, regardless of the number of respondents, highlighting the priorities perceived by each group throughout their academic journey. This approach provides valuable insights for planning educational interventions, allowing the identification of patterns that evolve as students progress through the course.

The data show marked differences in the priorities of students in each grade. In the 1st year, the main suggestion was the monitoring of the use of digital technologies (21.4%), demonstrating an initial need for supervision and guidance to ensure that resources are used productively. The second highest demand at this stage was for specific training (19.0%), reflecting the need for basic training for familiarization with digital and AI tools.

Specific spaces for learning (16.7%) and access to digital platforms (11.9%) also figured as significant priorities, suggesting that adequate infrastructure plays a crucial role in students' adaptation to the technical environment.

In Year 2, priorities change significantly, with technological devices being the top suggestion (20.0%). This may reflect the perception of insufficiency in existing infrastructure as students face more technical and advanced activities. Specific spaces (17.8%) and monitoring of use (13.3%) continue to be relevant, although with less emphasis in relation to the 1st year. The promotion of activities, such as workshops and awareness events (8.9%), presents low demand, possibly indicating that students in this grade are already more familiar with the resources offered.

In the 3rd year, the focus of the suggestions is on access to digital platforms (23.3%), highlighting the importance of robust and accessible tools for carrying out practical projects and final course activities. Specific spaces (18.6%) and the integration of AI (14.0%) also appear prominently, suggesting the need for advanced infrastructure and technological support aligned with the demands of completing the course. Monitoring of use (9.3%) and promotion of activities (7.0%) show a significant reduction compared to previous grades, reflecting a greater independence of students in this final stage.

Overall, the results indicate a clear evolution in priorities throughout the course. Year 1 is characterized by a greater need for supervision, training, and basic support, while Year 2 highlights demands related to infrastructure and technological devices. In the 3rd year, the focus turns to digital platforms and AI integration, reflecting the increased complexity of academic activities and preparation for the job market.

Although some categories, such as "specific spaces" and "access to platforms", remain relevant in all grades, the analysis highlights the importance of adjusting educational interventions to the specific needs of each stage. In Year 1, the focus should be on initial training and supervision; in the 2nd year, investments in technological devices and infrastructure become a priority; while in the 3rd year, the expansion of access to platforms and the greater integration of AI in activities are fundamental to prepare students for an autonomous and efficient use of these technologies.

The findings presented in the graph provide a solid basis for the formulation of targeted educational strategies, ensuring that digital technologies are effectively integrated at each stage of the technical course. This analysis highlights the need for pedagogical and structural interventions that keep up with the evolution of student demands, promoting an enriching educational experience that is aligned with the demands of the contemporary market.

ANALYSIS OF STUDENTS' SUGGESTIONS TO IMPROVE THE USE OF TECHNOLOGIES: RESULTS OF THE ANOVA TEST

The ANOVA test was applied with the objective of investigating statistically significant differences in suggestions for improvement for the use of digital technologies and artificial intelligence (AI) between the grades (1st, 2nd and 3rd years) of the technical course in Agriculture. This methodology is widely used to assess whether the variations in the means between groups outweigh the internal variability of the groups themselves, providing an objective criterion to verify the relevance of the observed differences. The choice of ANOVA, in this case, was motivated by the need to compare three distinct groups, ensuring statistical rigor in the analysis.

The results of the test showed an F-statistic of 1.41 and a p-value of 0.280, both indicating that there are no statistically significant differences between the suggestions made by the students throughout the grades. The F-statistic, which measures the relationship between intergroup and intragroup variability, revealed that the differences observed between the series are small in relation to the internal variability of each group. The p-value above 0.05 reinforces that these differences can be attributed to chance, and there is not enough evidence to reject the null hypothesis of equality between the means.

Although the results of the ANOVA test do not point to statistically relevant differences, the normalized graph illustrates important trends that, although not statistically significant, have practical implications for educational planning. For example, 1st year students highlighted "More Training" as a significant priority (19.0%), while in 3rd year the greatest emphasis was directed to "Platform Access" (23.3%). These differences may reflect the stage of academic development of students, where younger students demand greater guidance and initial training, while more advanced students value robust technological tools for practical activities and project completion.

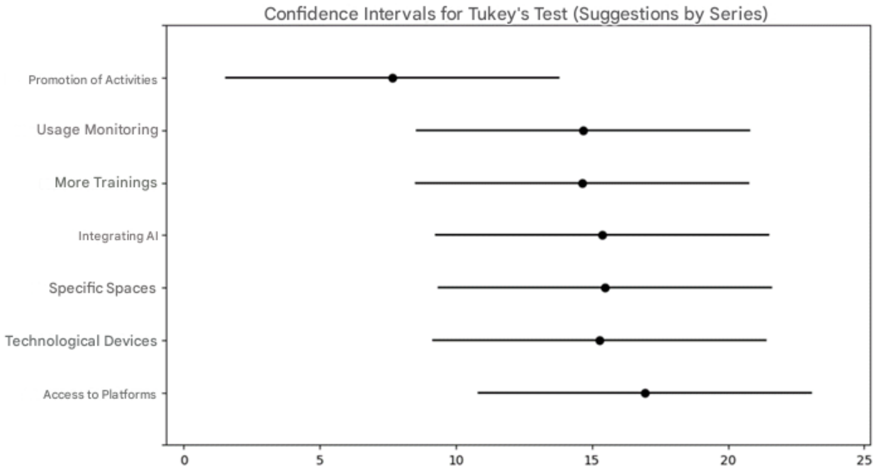
Another relevant observation is the consistent demand for "Specific Spaces" in all grades, with a slight reduction in the 3rd year. This suggests that physical infrastructure remains a cross-cutting need throughout the course. On the other hand, "Use Monitoring" and "Activity Promotion" showed a significant decrease in importance in the 3rd year, indicating that students develop greater independence as they advance in the course.

Even in the absence of statistical significance, the ANOVA test plays an essential role in validating the uniformity of the observed patterns. These results reinforce that students' perceptions and suggestions are relatively consistent across grades, but the nuances identified in the graph suggest that targeted pedagogical and structural adjustments can still bring significant improvements.

In conclusion, the ANOVA test demonstrated that there are no substantial differences between the grades with regard to suggestions for the use of digital technologies and AI, but the qualitative analysis of the trends evidenced by the graph allows valuable insights for the formulation of educational strategies. Targeted investments in initial training, technological infrastructure and access to platforms can meet the needs of students more effectively, ensuring a harmonious integration of technologies throughout the stages of the technical course.

ANALYSIS OF TUKEY'S TEST TO COMPARE SUGGESTIONS FOR IMPROVEMENTS IN THE USE OF TECHNOLOGIES

Graph 9: Tukey's Test Confidence Intervals for Suggestions for Improvements in the Use of Digital Technologies by Grade



Source: Survey Data

Tukey's test, used as a post-hoc analysis, was applied in this study to explore differences between the categories of suggestions presented by students to improve the use of digital technologies and artificial intelligence (AI) in technical education in Agriculture. This approach was performed after the ANOVA test, which identified the absence of statistically significant differences between the general groups. The use of Tukey's test is crucial in this context, as it allows comparing pairs of categories, providing confidence intervals that help identify nuances in the data, even when the differences do not reach statistical significance.

The graph shows the confidence intervals of the comparisons performed by Tukey's test. None of the comparisons showed statistical significance, since all adjusted p-values (P-adj) were higher than the significance level of 0.05. In addition, the confidence intervals of all comparisons include a value of zero, indicating that the differences observed between the means can be attributed to chance. For example, when comparing "Access to Platforms" with "Technological Devices", the confidence interval for the mean difference was from -13.95 to 10.62, demonstrating the absence of statistical significance and reinforcing the hypothesis of equality between the categories.

Although Tukey's test did not identify significant differences, the graph suggests some trends that may be relevant in the practical context. The category "Promotion of Activities", for example, presented more outstanding average differences in relation to other categories, but still without excluding the zero value in the confidence intervals. This trend may reflect a heightened perception of the importance of promoting awareness-raising and capacity-building activities related to the use of digital technologies.

The absence of statistically significant differences between the categories of suggestions indicates that students' perceptions of improvements in the use of technologies are relatively homogeneous. This homogeneity can be interpreted as a uniform need for improvements in several areas, including infrastructure, training, and usage monitoring. However, it is important to highlight that the absence of statistical significance does not imply that all categories have the same impact or practical relevance.

The results suggest that educational interventions should adopt a comprehensive approach, considering all categories as priorities. Despite the statistical homogeneity, practical differences between categories, such as the greater appreciation of "Promotion of Activities", may justify targeted efforts to meet specific demands. In addition, it is recommended to carry out complementary qualitative analyses or to expand the sample to better explore differences that were not statistically significant.

In conclusion, Tukey's test did not identify significant differences between the categories of suggestions, but the patterns observed highlight the importance of considering both statistical evidence and educational context when planning improvements in the use of technologies. A balanced approach aligned with the practical needs of students can contribute significantly to the effective integration of digital technologies in technical education.

The results obtained throughout this study revealed consistent patterns and important trends on the use of digital technologies in the technical course in Agriculture. Although no statistically significant differences were identified between the categories of suggestions, the qualitative analysis pointed out relevant nuances that can guide pedagogical decisions. It was observed that, while 1st year students value monitoring and basic training more, 3rd year students prioritize access to digital platforms and the integration of AI, reflecting their specific needs at each stage of training.

In addition, the data reinforce the importance of segmented pedagogical planning, capable of responding to the demands of students in a progressive way and aligned with the context of each grade. Investing in infrastructure, technical training, and the promotion of activities aimed at the ethical and effective use of digital technologies can enhance educational results and better prepare students for contemporary challenges. This study highlights the relevance of considering both statistical evidence and practical contexts when planning technological interventions, promoting a more efficient and meaningful integration of technologies in technical education.

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