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The Dawn of a New Agricultural Era: A Systematic Review of the Internet of Things in Agricultural Science Education

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Abstract
The Internet of Things (IoT) is profoundly transforming agriculture, creating an urgent need to adapt educational frameworks to prepare a future-ready workforce. This systematic review aims to synthesize the current state of knowledge on the integration of IoT into agricultural science education, examining its impacts, challenges, and future directions. Following PRISMA guidelines, a systematic search of the Scopus database for articles published between 2015 and 2025 was performed. From an initial 524 records, 18 studies were selected for thematic analysis. The key findings reveal three central themes: (1) the critical role of higher education in developing an IoT-skilled workforce through experiential, project-based learning; (2) the variable effectiveness of IoT educational tools, which is highly dependent on pedagogical strategy and student level; and (3) the strong correlation between education levels and the successful adoption of IoT technologies in the agricultural sector. In conclusion, while integrating IoT into agricultural education is essential, its success hinges on pedagogically sound implementation, not just technology deployment. It is recommended that policymakers support curriculum modernization and that educators adopt hands-on teaching frameworks. Future research should focus on developing standardized competencies and assessing the long-term career outcomes of these programs.

Keywords: Internet of Things (IoT); Agricultural Education; Precision Agriculture; Technology Adoption; Workforce Development.

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1. Introduction

The global agricultural landscape is undergoing a profound transformation, driven by the integration of digital technologies. At the heart of this revolution lies the Internet of Things (IoT), a network of interconnected devices that collect and exchange data, enabling unprecedented levels of monitoring and control (Maiti et al., 2019; Medvedev & Molodyakov, 2019). This paradigm shift towards data-driven agriculture holds immense promise for enhancing productivity (Khan & Babar, 2024; Mishra & Mishra, 2024), promoting sustainability (Duguma & Bai, 2025; Dutta et al., 2025), and ensuring global food security (Anjum et al., 2025; Sadiq et al., 2025). This systematic literature review, will explore the burgeoning intersection of this technology with the crucial field of agricultural education.

The imperative to review this topic at this juncture is multifaceted. The agricultural sector is grappling with significant challenges, including the impacts of climate change as stated by Artık et al. (2024) climate change has profound impacts on agriculture, including altered temperature and precipitation patterns, increased frequency of extreme weather events, and shifts in the geographic distribution of pests and diseases. Growing global population and the need for more sustainable farming practices are also common problems faced today (Arhin et al., 2024; Merwade et al., 2022). IoT offers potent solutions by enabling precision agriculture, where resources such as water and fertilizers are used more efficiently, and smart farming, which automates and optimizes agricultural operations (Dewi & Chen, 2020). However, the successful implementation of these technologies hinges on a workforce equipped with the necessary skills and knowledge. A significant research gap exists in understanding how agricultural science education is adapting to this technological wave (Medvedev & Molodyakov, 2019). There is a pressing need to move beyond the practical application of IoT in the field and to scrutinize how we are preparing future generations of agricultural scientists, technicians, and leaders. This review addresses the critical question of how educational frameworks are evolving to meet the demands of an increasingly digitized agricultural industry.

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Central to the discourse on IoT in agriculture are several key concepts and theories that will be explored in this review. Precision agriculture stands out as a core principle, emphasizing data-driven decision-making to optimize crop yields and resource management. This involves the use of sensors, drones, and other IoT devices to monitor soil conditions, crop health, and environmental factors with high spatial and temporal resolution (Rajak et al., 2023). Another critical concept is smart farming, which encompasses the application of IoT, data analytics, and automation to enhance the efficiency and sustainability of agricultural production systems (Sawicka et al., 2025). This includes automated irrigation systems, robotic harvesting, and livestock monitoring. Furthermore, the review will delve into the role of big data analytics and cloud computing as foundational pillars that support the collection, storage, and processing of the vast amounts of data generated by IoT devices in an agricultural context (Aliar et al., 2022).

Despite the enthusiasm surrounding the potential of IoT in agriculture, the existing literature reveals several debates, controversies, and under-explored areas. The high cost of implementation and the requirement for robust internet connectivity in often-remote rural areas present significant barriers to widespread adoption (Puppala et al., 2023). This creates a potential digital divide, where large-scale, well-funded farms can leverage the benefits of IoT while smaller operations are left behind. Data privacy and security also emerge as contentious issues, with questions surrounding the ownership and protection of sensitive farm data (Kaur et al., 2022). A significant, and largely under-explored, area within this landscape is the pedagogical approach to teaching these complex technologies within agricultural science programs (Rehman et al., 2023). While many studies focus on the technical aspects of IoT in agriculture, there is a dearth of research on effective educational strategies, curriculum development, and the identification of essential competencies for students.

Therefore, the specific purpose of this systematic literature review is to synthesize the articles selected from journal databases to understand the current state of IoT integration in agricultural science education. This review seeks to identify the key themes, challenges, and opportunities presented in the existing literature. By systematically mapping the landscape of research at the intersection of IoT and agricultural education, this study aims to answer the following research question: What is the current state of knowledge regarding the integration of the Internet of Things into agricultural science education, including its impacts, challenges, and future directions? This synthesis will not only highlight the progress made but also illuminate the critical gaps that require further scholarly inquiry, ultimately contributing to the development of a more effective and future-ready agricultural science education.

2. Methods

This systematic literature review was conducted and reported by adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The adoption of the PRISMA framework ensures a transparent and rigorous methodological approach, allowing for the replication of the review process. The research design is a systematic review of primary scientific articles focused on the intersection of the Internet of Things (IoT) and agricultural science education which can be seen in full in Figure 1.

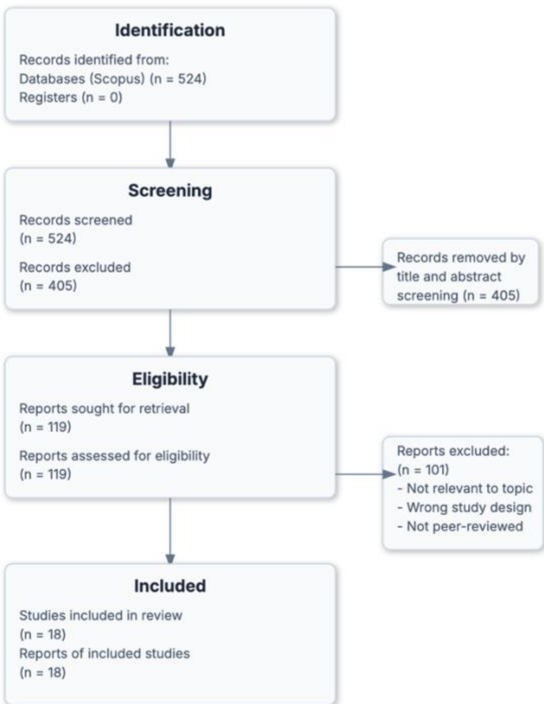

Figure 1 PRISMA flow diagram

2.1 Eligibility Criteria

The inclusion and exclusion criteria were established prior to the literature search to ensure the selection of relevant studies. This review considered scientific articles that presented primary data, encompassing both qualitative and quantitative research designs. To maintain a contemporary focus on this rapidly evolving field, the publication year was restricted to a ten-year window, from 2015 to 2025. Only articles published in the English language were included to ensure a consistent linguistic basis for analysis. Studies were excluded if they were not peer-reviewed, such as conference proceedings, book chapters, or dissertations that had not undergone this level of academic scrutiny. Furthermore, articles were excluded if they were not directly relevant to the core topic of IoT in the context of agricultural science education.

2.2 Information Sources

The Scopus electronic database was the primary source for identifying relevant literature. The choice of Scopus is justified by its comprehensive and interdisciplinary nature, offering extensive coverage of peer-reviewed journals in technology, agriculture, and education. Scopus is renowned for its stringent indexing criteria, ensuring the inclusion of high-quality research. Its advanced search functionalities and citation tracking also facilitate a thorough and robust search process, minimizing the risk of omitting significant studies.

2.3 Search Strategy

A comprehensive search string was developed to capture the relevant literature. The final search query used was: ("IOT" OR "Internet of Things" AND "Education" AND "Agriculture"). The development of this search strategy was an iterative process. An initial broad search using "Internet of Things" and "Agriculture" yielded a vast number of articles, most of which focused on the technical application of IoT in the agricultural industry rather than on educational aspects. To refine the search, the keyword "Education" was added. The term "IOT" was also included as an alternative to "Internet of Things" to capture articles that use this common acronym. This more targeted search strategy proved effective in isolating a more relevant set of articles for screening.

2.4. Study Selection Process

The study selection was a multi-stage process conducted by two independent reviewers to minimize selection bias. In the first stage, the reviewers independently screened the titles and abstracts of all articles retrieved from the Scopus database against the pre-defined eligibility criteria. Articles that clearly did not meet the criteria were excluded. In the second stage, the full texts of the remaining articles were retrieved and independently assessed by the same two reviewers for final inclusion. Any discrepancies between the reviewers at either the title/abstract screening or the full-text screening stage were resolved through discussion and consensus. If an agreement could not be reached, a third reviewer, with expertise in the field, was consulted to make the final decision.

2.5. Data Extraction Process

A standardized data extraction form was developed and used to systematically collect relevant information from each of the included studies. This ensured consistency in the data collected and facilitated subsequent analysis. The information extracted from each article included: the author(s), year of publication, study objectives or research questions, the methodology employed, and the main findings or conclusions relevant to IoT in agricultural science education.

2.6. Quality Assessment/Risk of Bias

The methodological quality and risk of bias of the included studies were assessed using the Newcastle-Ottawa Scale (NOS). The NOS is a validated tool designed to assess the quality of non-randomized studies, which were anticipated to be a common study design in this area of research. The scale evaluates studies based on three main criteria: the selection of the study groups, the comparability of the groups, and the ascertainment of either the exposure or outcome of interest.The quality assessment was conducted independently by two experts in agricultural science education. Each study was scored based on the NOS criteria, and any disagreements in scoring were resolved through discussion and a final consensus rating was assigned. This process helped to ensure a reliable and objective assessment of the quality of the evidence base.

2.7. Data Synthesis

The data extracted from the selected articles were synthesized using a thematic analysis approach. Thematic analysis is a qualitative method for identifying, analyzing, and reporting patterns or themes within the data. This process involved several stages: first, the reviewers familiarized themselves with the extracted data by repeatedly reading it. Next, initial codes were generated from the data, which were then collated into potential themes. These themes were subsequently reviewed, defined, and named. This systematic process allowed for a rich and detailed synthesis of the findings from the individual studies, leading to a comprehensive understanding of the current state of research on the Internet of Things in agricultural science education.

For new methods and protocols, provide a detailed description. For well-established methods, provide a brief summary and appropriate references.

3. Results

This section presents the results of the systematic literature review. The search and screening process, guided by the PRISMA framework, began with an initial 524 articles identified through the Scopus database. Following a thorough title and abstract review, this number was reduced to 119 articles. A subsequent full-text review against the eligibility criteria resulted in a final selection of 18 studies for inclusion in this review. The findings from these articles are synthesized and presented below.

3.1. Characteristics of Included Studies

The 18 articles included in this review provide a contemporary snapshot of the research landscape, with publication dates ranging from 2018 to 2025. The studies employ a variety of methodologies, including case studies, quasi-experimental designs, surveys, and the development of technological frameworks. The key characteristics and findings of each study are summarized in Table 1.

Table 1 Summary of Included Studies

Author(s) & Year	Title	Method	Key Findings
(Lin & Lin, 2025)	The Effectiveness of Developing Cloud-Based Agricultural Environmental Sensing System to Support Food and Agriculture Education in Elementary School	Quasi-experiment	The use of a cloud-based IoT system did not result in significant differences in learning achievements, motivation, or attitudes for elementary school students compared to traditional methods.
(Bampasidou et al., 2024)	Overcoming 'Digital Divides': Leveraging higher education to develop next generation digital agriculture professionals	Article (Argumentative)	Higher education and extension programs have a critical role in bridging knowledge and skills disparities in the agricultural sector by imparting technological know-how and addressing the ethics of emerging technologies.
(Kalfas et al., 2024)	Integration of Technology in Agricultural Practices towards Agricultural Sustainability: A Case Study of Greece	Survey (Questionnaire)	Technology integration, including IoT, has a significant positive effect on agricultural sustainability. The study emphasizes the importance of farmer education to facilitate technology adoption.
(Kondoyanni et al., 2024)	Adding Machine-Learning Functionality to Real Equipment for Water Preservation: An Evaluation Case Study in Higher Education	Case Study	An educational activity involving agricultural engineering students using IoT and machine learning was feasible and led to significant educational outcomes, improving their capacity for innovation and cooperation.
(Raja Subramanian et al., 2024)	SHAPE: Design and Evaluation of a Transformative Model for Engineering Education	Case Study (Mixed-methods)	A student-centered, project-based learning model (SHAPE) using IoT in an engineering course focused on agriculture resulted in a 5% increase in average student performance and high levels of engagement.
(Yang et al., 2024)	Adoption of internet of things-enabled agricultural systems among Chinese agro-entreprises	Survey (Cross-sectional)	Knowledge about IoT-enabled agricultural systems (IAS) and a positive attitude were key predictors of agro-entrepreneurs' intention to adopt IAS.
(Quy et al., 2023)	AI and Digital Transformation in Higher Education: Vision and Approach of a Specific University in Vietnam	Case Study / Vision Paper	AI and IoT are transformative technologies for higher education, enabling smart and ubiquitous learning environments, though implementation in low- and middle-income countries faces challenges.
(Hua et al., 2023)	The design and implementation of a distributed agricultural service system for smallholder farmers in China	System Design & Case Study	A low-cost, intelligent agricultural service system was designed to bridge the digital divide for smallholder farmers, who often face challenges including low levels of education.
(Ahmed et al., 2022)	Integrating IoT Technologies into the CS Curriculum at PVAMU: A Case Study	Case Study	Integrating project-based IoT learning modules into a Computer Science curriculum had positive impacts on student interest and learning about IoT technologies relevant to fields like agriculture.
(Baz, 2022)	Developing and application to the fishing industry with the internet of thing (IoT)	System Design & Application	An IoT application to monitor pH and temperature in aquaculture was successfully designed and found to benefit fish producers.
(Kagan et al., 2022)	Special report: The Internet of Things for Precision Agriculture (IoT4Ag)	Report	Describes the establishment of a multi-institutional NSF Engineering Research Center (IoT4Ag) aimed at creating IoT technologies and training a diverse workforce for precision agriculture.
(Laha et al., 2022)	Advancement of Environmental Monitoring System Using IoT and Sensor: A Comprehensive Analysis	Review	Provides a comprehensive analysis of IoT's role in environmental monitoring, including applications in agriculture, to achieve global sustainability.
(Mahdi et al., 2021)	An improved chacha algorithm for securing data on IoT devices	Algorithm Design & Test	Proposed a new encryption algorithm to enhance data security for low-power IoT devices used in sectors including agriculture and education.

(Mijailović et al., 2021)	A cloud-based with microcontroller platforms system designed to educate students within digitalization and the industry 4.0 paradigm	System Design & Analysis	Developed a cloud-based IoT system for educating students in engineering, agriculture, and ecology, noting a lack of specialized educational courses in these areas.
(Zuo et al., 2021)	Flying over the farm: understanding drone adoption by Australian irrigators	Regression Analysis	Higher education levels were positively associated with Australian irrigators' plans to adopt drone technology for precision agriculture.
(Ahad et al., 2020)	Enabling technologies and sustainable smart cities	Review	Discusses how IoT is a core enabling technology for automating smart ecosystems, including agriculture and education, within the broader context of smart cities.
(Sun et al., 2018)	Design and realization of intelligent service system for monitoring and warning of meteorological disasters in facility agriculture in North China	System Design & Realization	An intelligent IoT-based system was successfully built to provide real-time meteorological disaster warnings and production guidance for farmers.
(Sashika et al., 2024)	Exploring the evolving landscape: Urban horticulture cropping systems–trends and challenges	Review	Identifies IoT as a key trend in urban horticulture and highlights the vital role of advocacy and education in gaining public support and encouraging involvement.

3.2. Thematic Synthesis of Findings

Thematic analysis of the 18 studies revealed three primary themes: (1) The Role of Higher Education in IoT-Driven Agricultural Workforce Development, (2) The Application and Effectiveness of IoT Educational Tools, and (3) The Broader Context of Technology Adoption and the Need for Education.

3.2.1. The Role of Higher Education in IoT-Driven Agricultural Workforce Development

A significant portion of the literature centers on the critical function of higher education in preparing a new generation of agricultural professionals. The studies consistently find that there is a recognized need to integrate IoT and digital technologies into formal curricula. Bampasidou et al. (2024) argue that academic programs must play a larger role in developing an "AI-ready workforce" by providing upskilling and reskilling opportunities to bridge the "digital divides" in the agricultural sector. This sentiment is echoed by Kagan et al. (2022), who report on the establishment of a major, multi-university Engineering Research Center (IoT4Ag) specifically designed to train a diverse workforce capable of advancing food and water security through IoT.

Several studies provide direct evidence of the positive outcomes of such integration. Kondoyanni et al. (2024) found that a hands-on project for agricultural engineering students using IoT and machine learning for water preservation significantly improved their capacity for innovation and cooperation. Similarly, Raja Subramanian et al. (2024) demonstrated that a project-based learning framework incorporating IoT in an engineering course led to a measurable increase in student performance and high levels of engagement. The integration is not limited to agriculture departments; Ahmed et al. (2022) reported positive impacts on student interest by integrating IoT learning modules into a Computer Science curriculum, with agriculture cited as a key application domain. The need for these educational initiatives is further underscored by Mijailović et al. (2021), who noted a general lack of specialized courses on these topics before developing their own educational system for engineering and agriculture students.

3.2.2. The Application and Effectiveness of IoT Educational Tools

The second theme focuses on the development and evaluation of specific systems and tools for educational purposes. The findings here show a general consistency in the successful development of such tools, but a point of inconsistency regarding their measured effectiveness on learning outcomes. Several studies report on the successful design and implementation of IoT-based systems for educational or training purposes, such as the cloud-based platform for educating agriculture students by Mijailović et al. (2021) and the intelligent service system for farmers by Sun et al. (2018).

However, the most direct evaluation of learning impact presented a unique finding. The quasi-experimental study by Lin & Lin (2025) stands out as it found that using a cloud-based agricultural environmental sensing system in an elementary school setting resulted in no significant differences in learning achievements, motivation, or attitudes compared to a control group using traditional methods. This finding contrasts with the more qualitative or performance-based assessments from studies in higher education, such as those by Kondoyanni et al. (2024) and Raja Subramanian et al. (2024), which reported significant positive outcomes. This suggests that the pedagogical approach and educational level may be critical factors in the successful application of IoT tools for learning.

3.2.3. The Broader Context of Technology Adoption and the Need for Education

The final theme situates the need for agricultural science education within the broader context of technology adoption in the field. The findings consistently link education and knowledge to the successful adoption of IoT technologies by farmers and agricultural enterprises. The study of Greek farmers by Kalfas et al. (2024) found that while technology integration positively impacts sustainability, farmer education is crucial to facilitate adoption. This is directly supported by research on Australian irrigators, where Zuo et al. (2021) found that a higher education level was a positive predictor of plans to adopt drone technology.

Furthermore, research on Chinese agro-entrepreneurs by Yang et al. (2024) revealed that knowledge about IoT systems was one of the strongest predictors of the intention to adopt them. The challenge is particularly acute for smallholder farmers, as highlighted by Hua et al. (2023), who note that low levels of education contribute to a "digital divide," which their proposed service system aims to address. These studies from the field provide a clear, evidence-based justification for the educational initiatives described in Theme 1, creating a feedback loop where the needs of the industry directly inform the curriculum in agricultural science education.

4. Discussion

This systematic literature review sought to synthesize the current state of knowledge regarding the integration of the Internet of Things (IoT) into agricultural science education. The analysis of 18 pertinent studies revealed three central themes: the pivotal role of higher education in developing a future-ready agricultural workforce, the mixed effectiveness of specific IoT educational tools, and the foundational importance of education in driving technology adoption in the agricultural sector. This section interprets these key findings, discusses their broader implications, acknowledges the review's limitations, and proposes directions for future research.

4.1. Interpretation of Key Findings

This review provides a clear answer to the central research question by demonstrating that the integration of IoT into agricultural science education is an active, yet nascent, field of research and practice. The findings collectively illustrate a strong consensus on the *need* for this integration, driven by the technological transformation of the agricultural industry. However, the *methods* and measured *outcomes* of this integration are still emerging and show some variability.

The first theme, focusing on higher education's role in workforce development, aligns with the broader discourse on Industry 4.0 and its impact on all sectors. The argument put forth by Bampasidou et al. (2024) for higher education to bridge the "digital divides" is a powerful one, positioning universities not just as centers of learning but as crucial agents in ensuring equitable technological transition. The successful case studies from Kondoyanni et al. (2024), Raja Subramanian et al. (2024), and Ahmed et al. (2022) provide concrete evidence that hands-on, project-based learning can effectively equip students with the necessary skills in IoT. This trend highlights a significant shift in engineering and agricultural pedagogy away from purely theoretical instruction towards experiential learning that mirrors real-world challenges. The establishment of the IoT4Ag center (Kagan et al., 2022) further solidifies this trend, indicating a systemic, multi-institutional recognition of this educational imperative.

The second theme, concerning the application and effectiveness of IoT educational tools, reveals a more complex picture. The consistency in the successful *development* of educational platforms (Mijailović et al., 2021; Sun et al., 2018) is encouraging. However, the standout finding from Lin & Lin (2025)—that an IoT-based system showed no significant learning benefit over traditional methods in an elementary school setting—is a crucial counterpoint. This inconsistency suggests that the efficacy of educational technology is not universal but highly context-dependent. The discrepancy between this finding and the positive results seen in higher education settings could be attributed to several factors. The cognitive development of learners, the pedagogical approach (passive monitoring vs. active problem-solving), and the complexity of the technology itself may play significant roles. This finding challenges the often-implicit assumption that simply introducing technology into the classroom will automatically enhance learning. It underscores the need for carefully designed, age-appropriate pedagogical strategies to accompany the hardware.

The final theme, which connects education to technology adoption, reinforces the foundational importance of this review's topic. The consistent findings from Greece (Kalfas et al., 2024), Australia (Zuo et al., 2021), and China (Yang et al., 2024; Hua et al., 2023) create a compelling global narrative: knowledge and education are key drivers of technology adoption in agriculture. This pattern refutes any notion that technology can be implemented in a vacuum. It contributes to a deeper understanding of the socio-technical nature of agricultural transformation, highlighting that human capital is as critical as technological innovation. This theme provides a strong rationale for policy and investment in agricultural education as a direct means of fostering a more productive, sustainable, and technologically advanced agricultural sector.

4.2. Implications for Policy, Practice, and Research

The findings of this review have significant implications. For policymakers, the evidence strongly supports increased investment in the modernization of agricultural science curricula at all educational levels. This includes funding for curriculum development, teacher training, and the acquisition of necessary laboratory equipment to provide hands-on experience with IoT technologies. The link between education and technology adoption suggests that such investments are not merely an educational expenditure but a strategic investment in the future of the agricultural economy.

For educational practitioners, the review highlights the value of project-based, experiential learning approaches, particularly in higher education. The challenge lies in adapting these methods for different age groups and educational contexts. The findings from Lin & Lin (2025) serve as a caution against a one-size-fits-all approach, emphasizing the need for educators to design learning experiences that are not just technologically rich but also pedagogically sound.

Theoretically, this review contributes to the literature by systematically mapping the intersection of IoT and agricultural science education, a previously underexplored area. It identifies a clear trend towards educational reform driven by industrial change and highlights the complexities of evaluating educational technology effectiveness.

4.3. Strengths and Limitations

The primary strength of this literature review lies in its rigorous and transparent methodology, following the PRISMA guidelines. This systematic approach, including the use of two independent reviewers for study selection and a formal quality assessment, enhances the reliability and replicability of the findings. The focus on the Scopus database, while a limitation in one sense, also ensures that the included articles have met a high standard of peer review.

However, several limitations must be acknowledged. First, the reliance on a single database (Scopus) means that relevant articles indexed in other databases (e.g., Web of Science, Agricola) may have been missed. Second, the exclusion of non-English articles may introduce a language bias, potentially overlooking relevant research from non-Anglophone countries. Third, like all reviews, this study is susceptible to publication bias, where studies with significant or positive findings are more likely to be published than those with null or negative results. The inclusion of the study by Lin & Lin (2025) with its null findings is therefore particularly valuable, but it is possible other such studies exist and were not published. These limitations mean the findings should be interpreted as representative of the literature within the defined search parameters, rather than an exhaustive account of all existing research.

4.4. Future Research Directions

Based on the gaps and trends identified in this review, several avenues for future research are recommended.

1. Longitudinal Studies: There is a need for longitudinal studies that track the long-term career outcomes of students who have participated in IoT-focused agricultural education programs. This would provide stronger evidence for the effectiveness of these programs in preparing graduates for the demands of the industry.
2. Comparative Pedagogical Research: New research should directly compare different pedagogical approaches for teaching IoT concepts. For example, studies could compare project-based learning versus traditional lecture-based methods, or evaluate the effectiveness of these approaches across different educational levels (secondary vs. higher education).
3. Curriculum Standardization and Assessment: Research is needed to develop and validate a core set of competencies for IoT in agriculture. This could lead to the creation of standardized curricula and assessment tools that would help ensure quality and consistency across different educational institutions.
4. Exploring the "Digital Divide" in Education: While Bampasidou et al. (2024) raise the issue, more empirical research is needed to understand how access to and the quality of IoT education varies between different socioeconomic and geographic contexts.

This review has illuminated the emergence of a new and vital subfield within agricultural science. The question is no longer *if* IoT should be integrated into the curriculum, but *how* it can be done most effectively, equitably, and in a way that truly empowers the next generation to lead the future of agriculture.

5. Conclusions

this systematic review determines that integrating the Internet of Things into agricultural science education is an essential and developing field, directly responding to the technological evolution of the agricultural industry. The principal findings underscore a strong agreement on higher education's crucial role in creating a skilled workforce through practical, project-based learning. However, the effectiveness of IoT educational tools varies, with evidence indicating that the pedagogical strategy and the educational level of the students are critical determinants of success, questioning the notion that technology inherently improves learning outcomes. A clear connection is established between the educational attainment of agricultural professionals and their adoption of IoT technologies, highlighting that human capital is as vital as technological innovation. Therefore, recommendations include increased policy investment to modernize agricultural curricula and the adoption of experiential, pedagogically sound teaching frameworks by educators. Future research should prioritize longitudinal studies on career outcomes, comparative analysis of teaching strategies, and the creation of standardized competencies to prepare the next generation for the future of agriculture effectively and equitably.

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Ethical considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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