TRANSFORMING TEACHING AND LEARNING WITH ROBOTIC PROCESS AUTOMATION: A SYSTEMATIC REVIEW OF PEDAGOGICAL APPLICATIONS

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ABSTRACT

Aim/Purpose	Robotic Process Automation (RPA) is revolutionizing education by automating repetitive tasks, enhancing personalized learning, and optimizing assessment processes. This study examines how RPA transforms pedagogical practices, improves student engagement, and enables educators to focus on high-value instructional strategies. Through a systematic literature review, this research synthesizes best practices and identifies key opportunities for maximizing the impact of RPA on teaching and learning.
Background	The digital transformation of education is reshaping how institutions deliver teaching and learning. Within this landscape, automation has become central to educational reform, yet its pedagogical implications remain insufficiently understood. Although RPA has been widely adopted in business contexts, its application in education is still emerging, with limited evidence on how it contributes to teaching effectiveness, student engagement, and institutional sustainability. This gap underscores the importance of a systematic review to consolidate current knowledge.
Methodology	A systematic literature review following PRISMA methodology was conducted, analyzing peer-reviewed studies (2019-2024) from Web of Science, Scopus, and

	Google Scholar. Thematic analysis was applied to extract trends, benefits, and implementation challenges.
Contribution	This systematic review synthesizes evidence from 17 peer-reviewed studies, moving beyond the conventional emphasis on administrative efficiency to highlight pedagogical applications of RPA. It identifies how RPA supports adaptive learning, enhances student engagement, and facilitates data-driven decision-making in education. The study also proposes a structured framework to guide integration strategies.
Findings	The synthesis of the reviewed studies indicates that RPA is not merely an administrative tool but also has the potential to act as a catalyst for pedagogical transformation. The literature highlights five main areas of impact: (1) personalized learning, by dynamically adapting educational content to students' progress; (2) automated assessment and feedback, enhancing grading accuracy and providing data-driven insights; (3) student behavior analysis, supporting early identification of learning gaps; (4) experiential and simulated learning, making education more immersive, and (5) optimization of teacher time, enabling educators to prioritize higher-order instructional strategies.
Recommendations for Practitioners	Institutions should prioritize RPA adoption in areas such as assessment, tutoring, and student engagement, where automation can demonstrably reduce workload and enhance instructional quality. Implementation should be accompanied by technical training and collaboration with IT professionals to ensure sustainability.
Recommendations for Researchers	Future research should investigate how RPA integrates with AI-driven systems (e.g., adaptive learning models, natural language processing) to support personalized and scalable educational practices. Longitudinal and cross-institutional studies are also needed to assess sustained impacts on teaching efficiency and student outcomes.
Impact on Society	By democratizing access to personalized education, RPA reduces teacher workload and enhances learning equity, particularly in underfunded institutions. If properly implemented, RPA can bridge gaps in educational quality and foster more inclusive learning environments.
Future Research	Further studies should investigate the integration of RPA with AI-driven models to enhance automated feedback and grading. Research should also address competency development, scalable implementation, and barriers to adoption.
Keywords	robotic process automation, RPA, pedagogical innovation, intelligent tutoring, personalization of learning

INTRODUCTION

Robotics has undergone significant evolution over the past decades, leading to the development of various types of robots categorized by their purpose and capabilities, such as industrial, service, and autonomous robots. These technologies have proven effective in environments requiring precision, repetitive tasks, or operations that pose risks to humans. Traditionally, robots have been physical entities designed to interact with the physical world. However, the advent of Robotic Process Automation (RPA) has introduced a new paradigm: software-based automation that operates exclusively in digital environments. Unlike traditional robotics, RPA employs software robots to execute repetitive, rule-based tasks, mimicking human interactions with digital applications and databases. This technology is transforming various industries, including education, by automating administrative and instructional tasks (Mamidyala & Balusu, 2024; Turcu & Turcu, 2021).

The global RPA market was valued at USD 18.18 billion in 2024 and is projected to reach USD 22.58 billion in 2025. By 2032, it is expected to grow to USD72.64 billion, reflecting a compound annual growth rate (CAGR) of 18.2% (Fortune Business Insights, 2025). This expansion is driven by the growing adoption of cloud-based RPA solutions, integration of AI and machine learning into automation workflows, and the increasing demand for cost efficiency in sectors such as banking, retail, healthcare, and education.

In the educational sector, RPA supports instructional automation, for instance, by streamlining grading and feedback generation, which improves accuracy and provides timely responses to students (Heins & Grunwald, 2024; Moşteanu, 2022). Beyond operational gains, RPA enables personalized learning by analyzing student behavior data and adapting content to individual progress, as demonstrated by early-warning systems capable of predicting performance risks within the first weeks of a course (Hu et al., 2024). Moreover, RPA has been applied in experiential and simulated learning environments, where automated analytics within serious games support interactive, game-based education (Qasrawi et al., 2020). Collectively, these applications demonstrate how RPA not only optimizes institutional processes but also directly contributes to improved student learning outcomes (Gunawan & Wijaya, 2023). Despite its growing adoption, current research on RPA in education remains fragmented, with most studies focusing on isolated applications, such as assessment automation or administrative process optimization.

While these works provide valuable insights, they lack a comprehensive framework that examines the broader pedagogical impact of RPA. At the same time, the number of empirical studies has grown steadily since 2019, providing a sufficient evidence base for a systematic review. Conducting such a review is therefore essential to consolidate dispersed findings, identify recurrent patterns across contexts, and highlight gaps that remain underexplored, such as long-term implications and adoption in low-resource educational settings (Gunawan & Wijaya, 2023). This study addresses these needs by synthesizing available evidence, mapping pedagogical contributions, and proposing a structured framework for integrating RPA into education.

Beyond its technical and operational advantages, the implementation of RPA in education raises important social and ethical concerns. While automation enhances efficiency and accessibility, it also introduces potential risks, such as data privacy violations, algorithmic bias in automated assessments, and the over-reliance on technology, which may reduce human engagement in learning (Gunawan & Wijaya, 2023). Additionally, there is an ongoing debate regarding whether RPA contributes to the deskilling of educators, as automation takes over traditionally manual tasks, potentially altering the role of teachers in the classroom. These challenges underscore the need for a responsible and equitable implementation of RPA that enhances rather than replaces human-led education.

In this context, the present study systematically reviews how RPA has been adopted and reported in educational literature. The review aims to consolidate fragmented findings, synthesize pedagogical and institutional implications, and highlight underexplored challenges. Accordingly, the study is guided by the following research questions:

(1) What is the current state of research on the application of RPA in education?
(2) What challenges have been identified in implementing RPA within educational contexts?
(3) What conceptual or empirical gaps remain in the literature that justify further investigation?

The following sections outline the methodology used for this systematic review, describe the PRISMA-based selection process and thematic analysis strategy, present the results organized by research questions and thematic categories, and critically discuss the implications of the findings. The discussion integrates prior literature and proposes a structured framework for implementing RPA in educational contexts. Finally, the conclusions summarize the main contributions, outline practical recommendations, and suggest future research directions.

METHODOLOGY

Building on this objective, this study employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology, as illustrated in Figure 1, to ensure scientific rigor and reproducibility (Moher et al., 2009). PRISMA is a widely recognized framework that enhances the transparency and reliability of systematic literature reviews. The methodology consists of several key stages: identification, screening, eligibility assessment, and data analysis (Ismail et al., 2021a, 2021b).

To enhance the robustness of our methodology, we adopted thematic analysis criteria that allowed for an in-depth interpretation of the qualitative data extracted from the studies. This approach ensured that key trends and insights related to RPA in education were systematically categorized. Furthermore, a list of excluded studies, along with the reasons for their exclusion, was documented to maintain transparency in the selection process.
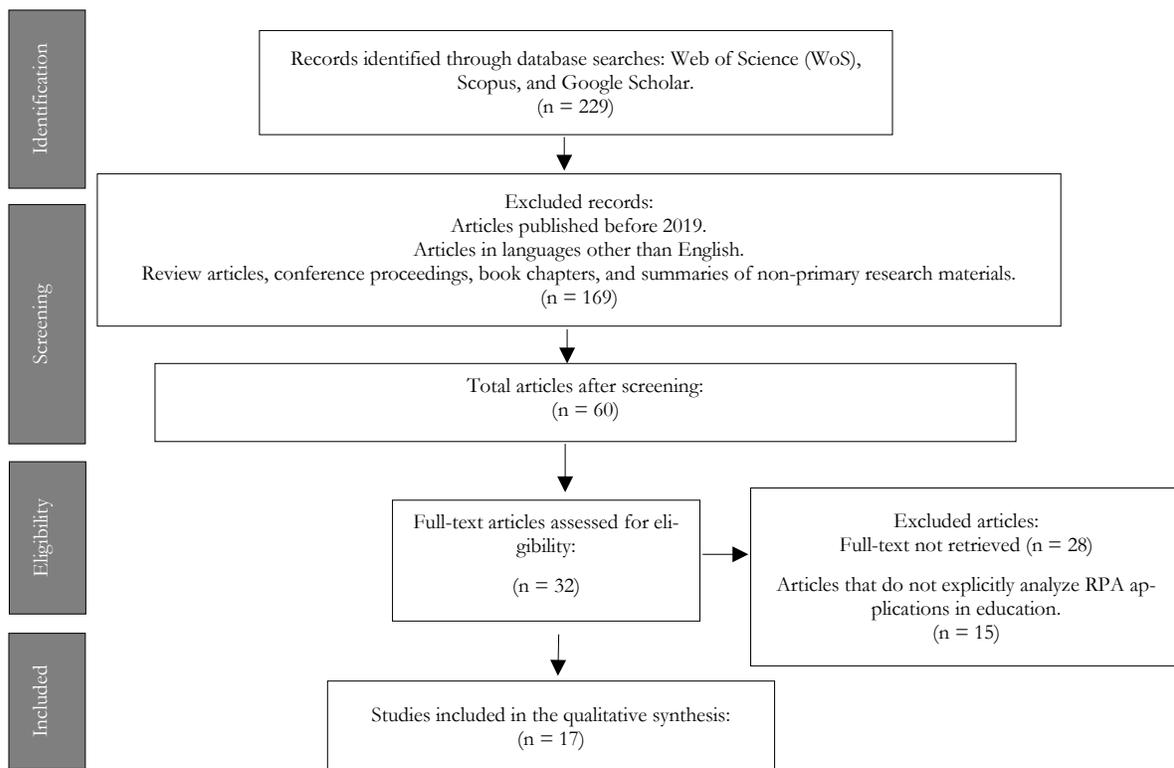
Figure 1. PRISMA framework for conducting a systematic literature review (adapted from Moher et al., 2009)

IDENTIFICATION

To ensure comprehensive coverage of relevant literature on RPA in education, a multi-database search strategy was employed. The selection of databases was based on their reliability, scope, and indexing quality in scientific research:

- *Web of Science (WoS):* Chosen for its extensive collection of peer-reviewed journals and its multidisciplinary coverage, ensuring high-quality sources.
- *Scopus:* Selected due to its wide array of publications in technology and education, allowing for a diverse set of studies.

- *Google Scholar:* Included to capture grey literature and studies from emerging research contexts, particularly where RPA applications in education may not yet be widely indexed in traditional databases (Zupic & Čater, 2015).

Specific keyword combinations and logical operators were applied consistently across Web of Science, Scopus, and Google Scholar to ensure relevance and accuracy in the search results. The final search strategy was:

- **Web of Science (WoS):**
  TS=(("robotic process automation" OR RPA) AND (educat* OR "higher education" OR universit* OR school* OR classroom OR teach* OR learn*))

- **Scopus:**
  TITLE-ABS-KEY(("robotic process automation" OR RPA) AND (educat* OR "higher education" OR universit* OR school* OR classroom OR teach* OR learn*))

- **Google Scholar:**
  ("robotic process automation" OR RPA) AND (educat* OR "higher education" OR universit* OR school* OR classroom OR teach* OR learn*)

SCREENING

All retrieved articles underwent a screening process based on predefined inclusion and exclusion criteria. These criteria ensured the selection of high-quality studies with empirical relevance:

- **Inclusion criteria:**
  Peer-reviewed journal articles (2019–2024) that provided empirical data on RPA in education, including studies on instructional automation, administrative efficiency, and personalized learning.

- **Exclusion criteria:**
  o Book chapters and non-English publications were excluded to avoid translation-related biases and inconsistencies. While conference proceedings were generally excluded, selected peer-reviewed conference papers were included when they demonstrated methodological rigor, thematic relevance, and empirical value in contexts where journal-based literature remains scarce (e.g., emerging applications of RPA in education).
  o Studies lack empirical data or offer only theoretical discussions without practical applications.
  o Articles that focused solely on automation in general education technology without specific reference to RPA.

To improve transparency, examples of excluded studies include:

- Studies discussing artificial intelligence (AI) in education, but not explicitly addressing RPA.
- Papers that mention automation but do not provide specific implementations or use cases related to RPA.
- Research on robotic tutors or physical robots used in education, as these fall outside the scope of software-based RPA.

After this phase, the dataset was refined to 60 articles.

ELIGIBILITY

A manual review was conducted to verify the relevance of the selected studies. Two independent reviewers evaluated each study based on:

- Clear application of RPA in education.
- Demonstrated benefits and practical implications.
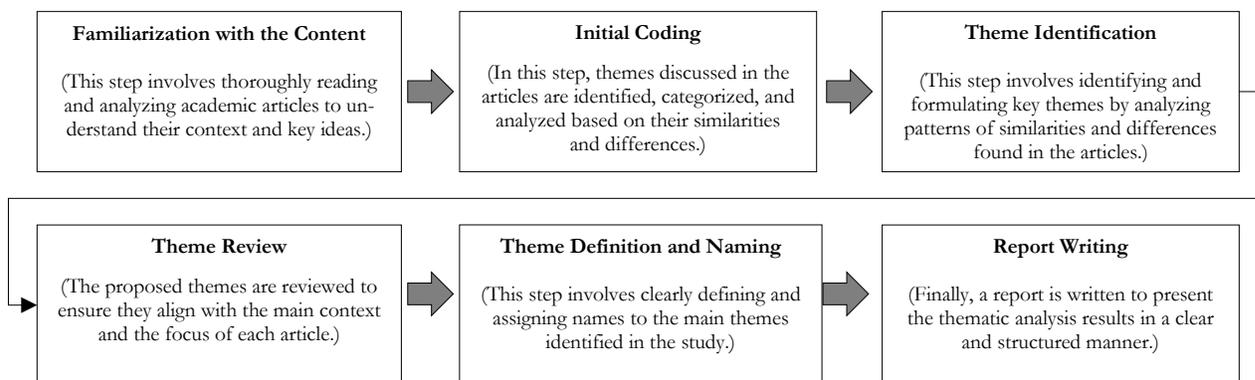- Availability of full-text access.

Studies that provided only theoretical discussions or lacked empirical evidence were excluded, and discrepancies were resolved through a consensus-based approach. To minimize selection bias, a double-blind review approach was implemented. Independent reviewers assessed the studies without prior knowledge of earlier screening decisions, ensuring that personal or institutional preferences did not influence the selection process. Additionally, a quality appraisal of the selected studies was performed to evaluate methodological robustness and consistency across the evidence base.

Of the 60 records after screening, 28 could not be retrieved in full text, plus 15 that were excluded for not explicitly analyzing RPA in education, resulting in 17 studies included in the final synthesis. Saturation was observed in the main categories – such as the automation of assessment, reduction of administrative workload, and personalized learning enhancements – which recurred consistently across multiple studies. At the same time, some subthemes were represented by only one or two articles, indicating areas where evidence remains limited. Therefore, while the sample was adequate to support robust findings in the core themes, further research is needed to expand emerging categories that are not yet sufficiently developed in the literature.

DATA ABSTRACTION AND ANALYSIS

In the final phase, a thematic analysis approach was applied to the selected studies. This method identifies and categorizes key themes related to RPA in education (Vaismoradi et al., 2013). Figure 2 illustrates this structured process. The analysis followed the six-step framework by Nowell et al. (2017), ensuring a systematic interpretation of findings.

To enhance reliability, intercoder agreement was established through independent cross-checking of thematic categorizations. Multiple researchers independently verified the theme classifications to ensure consistency and reduce subjectivity in the interpretation of findings.

Familiarization with the Content	Initial Coding	Theme Identification
(This step involves thoroughly reading and analyzing academic articles to understand their context and key ideas.)	(In this step, themes discussed in the articles are identified, categorized, and analyzed based on their similarities and differences.)	(This step involves identifying and formulating key themes by analyzing patterns of similarities and differences found in the articles.)
Theme Review	**Theme Definition and Naming**	**Report Writing**
(The proposed themes are reviewed to ensure they align with the main context and the focus of each article.)	(This step involves clearly defining and assigning names to the main themes identified in the study.)	(Finally, a report is written to present the thematic analysis results in a clear and structured manner.)

**Figure 2. Thematic analysis process in a systematic
literature review (adapted from Hijriyah et al., 2023)**

Specifically, two researchers independently coded an initial subset of the selected studies during the "Initial Coding" and "Theme Identification" stages of the thematic analysis process. The inductive coding process generated recurring codes, including "grading automation," "feedback generation," "student behavior monitoring," "administrative workload reduction," "adaptive content delivery," and "simulation-based learning." These codes were subsequently aggregated into broader categories (e.g., assessment automation, personalized learning, experiential learning), which correspond directly to the thematic categories presented in the Appendix. Divergences between coders were resolved collaboratively through multiple rounds of discussion until consensus was achieved on theme definitions and boundaries. This explicit mapping between codes, categories, and the tabulated synthesis ensures transparency and strengthens the analytical rigor of the review. Table 1 presents a synthesis of the 17 studies included in this review (see Appendix for full details).

Table 1. Synthesis of the 17 studies included

Author(s)	Year	Key findings
Heins & Grunwald	2024	RPA enabled 24/7 evaluation of digital learning artifacts, enhancing flexibility in personalized instruction.
Hu, Fu & Yeh	2024	RPA-based early-warning system achieved 71–72% predictive accuracy by week two.
Munawar	2024	444% efficiency gain; simplified teacher routines.
Qasrawi et al.	2020	Student success in simulations increased from 60% to 76.8% using RPA-driven analytics.
Lasso-Rodríguez & Gil-Herrera	2024	RPA significantly enhances human-robot interaction in educational contexts, facilitating more personalized and responsive learning experiences.
Phakdee et al.	2023	RPA reduced processing time by 71.42%, saving the equivalent of 1.65 full-time staff.
Felea et al.	2023	Faster document processing; reduced errors.
Supriyanto et al.	2023	Seamless integration with LMS; reduced manual tasks.
Paul et al.	2023	Higher satisfaction, efficiency gains.
Asif et al.	2023	Improved data security and auditability.
Maiti et al.	2023	Reduced admission cycle time by 60%.
Moşteanu	2022	Personalized learning and continuous monitoring.
Shinde & Kolhe	2022	Reduced workload; improved resource tracking.
Liu et al.	2022	Automation of expense reimbursement.
Subramanian et al.	2022	Time-saving in payroll and leave management.
El-Gayar et al.	2021	60% time reduction for data processing.
Yildiz et al.	2020	Increased efficiency and data accuracy.

RESULTS

The findings are organized according to the research questions posed, providing a comprehensive overview of how RPA contributes to advancing educational practices.

RQ1: WHAT IS THE CURRENT STATE OF RESEARCH ON THE APPLICATION OF RPA IN EDUCATION?

The analysis of the 17 included studies shows that research on RPA in education remains limited, with publications distributed between 2019 and 2024 and a modest peak in 2023. Early contributions primarily focused on administrative automation, while more recent studies have expanded into areas such as assessment, feedback generation, personalized learning, and experiential applications. This evidence highlights the fragmented and still emerging nature of the field, underscoring the need for systematic synthesis.

Building on these findings, the reviewed studies provide concrete evidence of how RPA has been applied in educational contexts. For instance, it has been shown to improve grading accuracy and timely feedback, support adaptive and personalized learning pathways (Moşteanu, 2022), enable early-warning analytics for student performance monitoring (Hu et al., 2024), enhance simulated and game-based learning environments (Qasrawi et al., 2020), and reduce administrative workloads through automation of attendance and reporting tasks (Munawar, 2021; Zahurin et al., 2024). Collectively, these applications illustrate the diverse yet fragmented ways in which RPA is currently being integrated into education.

Evolution of RPA research in education

Figure 3 illustrates the chronological distribution of the 17 studies published between 2019 and 2024. While the data show a modest peak in 2023, the overall volume remains low. Rather than signaling a strong upward trend, this pattern reflects the scarcity of research and the emerging status of RPA in the education sector. This limited evidence base reinforces the importance of conducting a systematic review at this stage to synthesize available insights and highlight areas that require further empirical exploration.
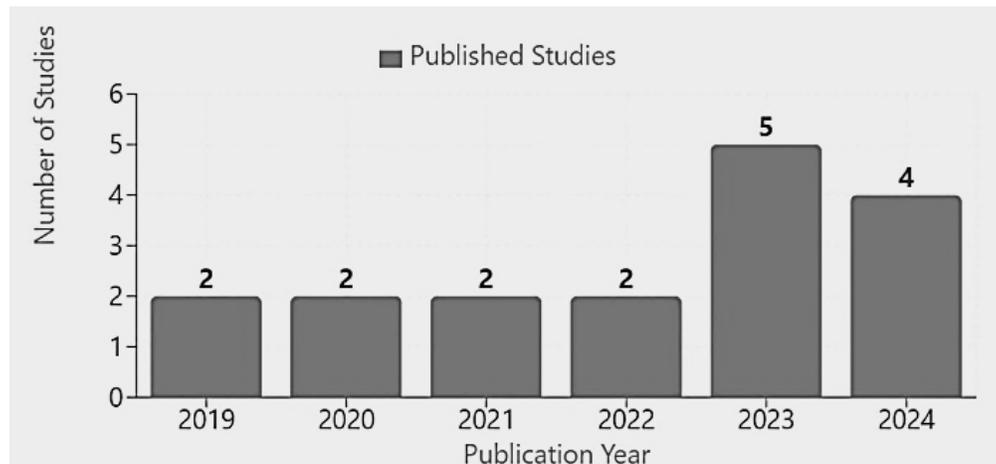
Figure 3. Chronological evolution of RPA research in educational contexts (2019-2024)

Geographical distribution of studies

Figure 4 highlights the global research landscape, showing that publications on RPA in education are geographically dispersed. Mexico (Universidad Americana de Europa) and Malaysia contribute the highest numbers of studies (four and three, respectively), while Germany, Romania, Indonesia, India, and several other countries are represented by single publications. This distribution indicates that current evidence reflects isolated contributions rather than sustained trajectories, with individual institutions pioneering initial applications of RPA in educational contexts.

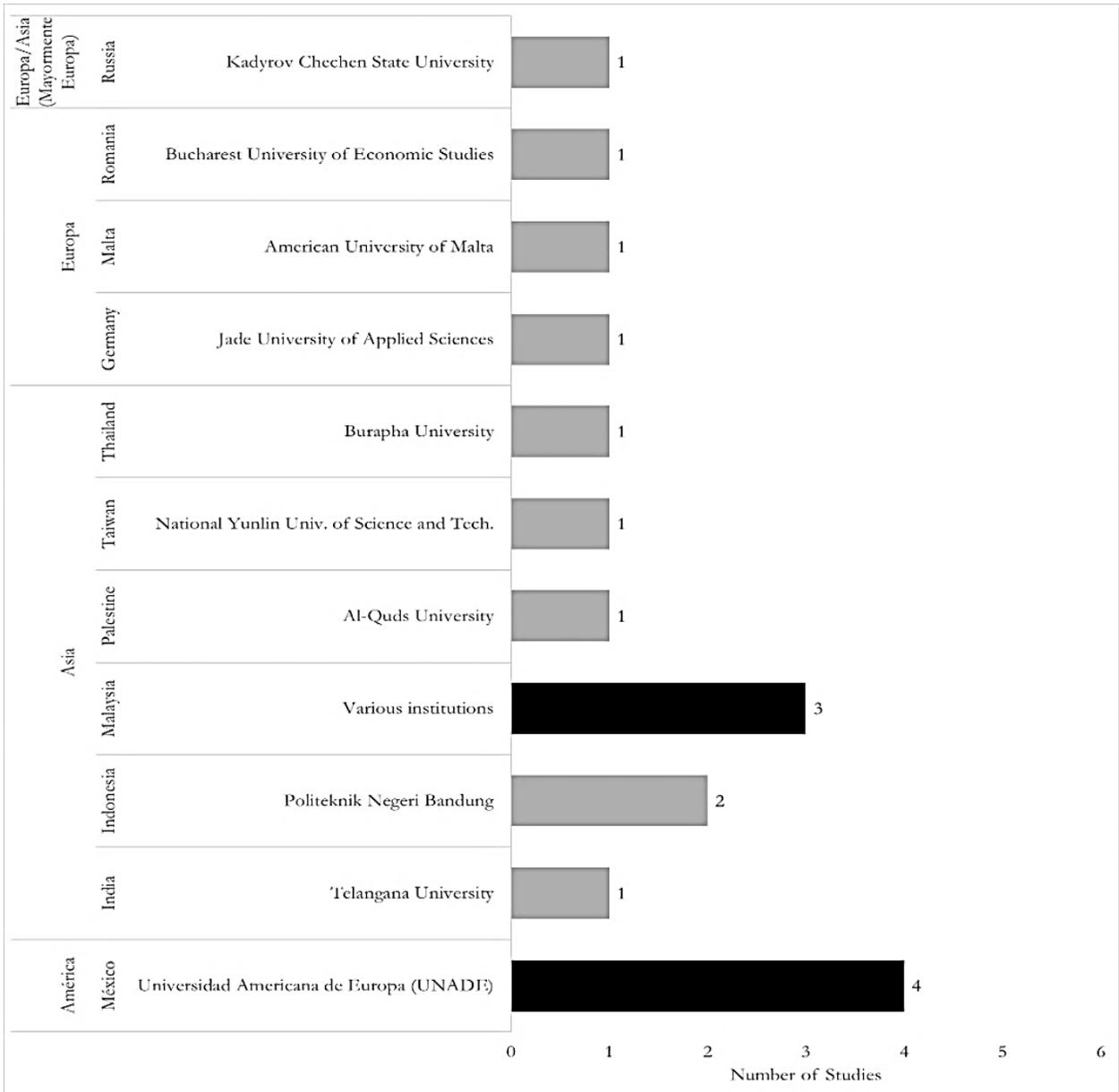## RPA technologies used in education

Figure 5 presents a breakdown of RPA tools utilized in educational applications. UiPath is the most widely used platform, appearing in 11 of 17 studies, followed by Microsoft Power Automate, Zapier, and Automation Anywhere. This dominance suggests that UiPath offers greater flexibility for educational automation.

## Applications of RPA in education

A systematic review of the literature categorizes RPA applications into five key areas. These areas were derived from an inductive coding process that initially generated a larger set of descriptive codes, such as "grading automation," "feedback generation," "student behavior monitoring," "adaptive content delivery," "attendance tracking," and "reporting." These codes were then clustered into higher-order categories, which were synthesized into the following five application areas: (1) automation of assessment and feedback (3 studies, 18%); (2) personalized learning (4 studies, 23%); (3) evaluation and analysis of student behavior (2 studies, 12%); (4) support in experiential and simulated learning (1 study, 6%); and (5) optimization of teacher time (7 studies, 41%).

Automation of assessment and feedback

Three distinct approaches to RPA in assessment were identified. Heins and Grunwald (2024) demonstrated the use of UiPath and Solibri to automate evaluation in BIM education, achieving higher grading consistency and reduced teacher workload through instant, data-driven feedback. Moşteanu (2022) integrated machine learning algorithms with RPA to generate personalized reports and identify performance patterns, enabling more targeted interventions in student progress. Younis et al. (2023) introduced NAO robots combined with RPA to deliver real-time verbal feedback, showing potential for interactive engagement in classroom activities.

Figure 4. Distribution of studies by country/institution
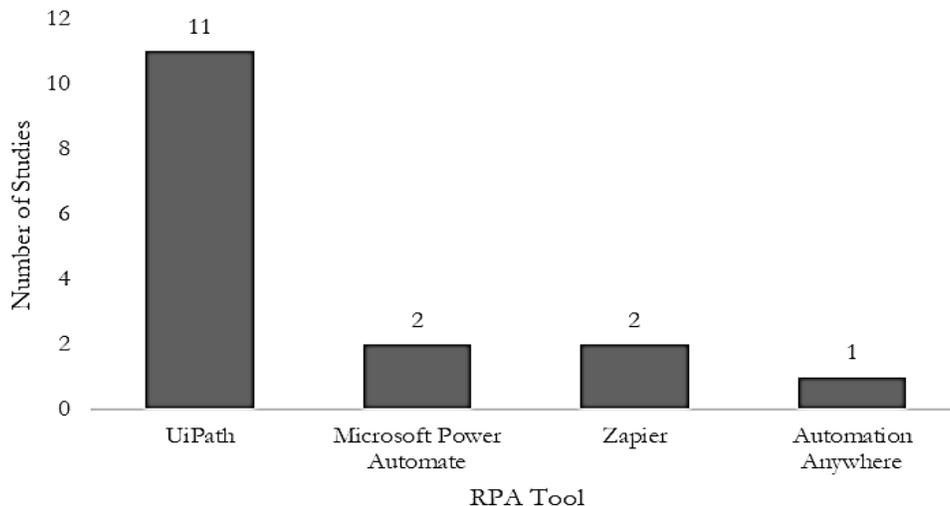
Figure 5. RPA technologies used in studies

Across the reviewed studies, the main advantages of RPA in assessment include:

- Reduction of teachers' workload through automation of repetitive grading tasks.
- Immediate, accurate, and personalized feedback to support student learning.
- Encouragement of self-directed learning by allowing students to review and refine their work.
- Enhanced performance monitoring for early detection of learning gaps and timely interventions.

Despite these benefits, several challenges remain:

- Technological infrastructure barriers: resource-constrained institutions may lack the capacity to support RPA systems.
- Teacher resistance: perceived complexity, job displacement concerns, and difficulties integrating RPA into existing workflows.
- Difficulty evaluating open-ended assignments: automation excels at structured tasks but struggles with essays, critical thinking, and project-based work.

Personalized learning

Several studies have examined how RPA supports personalized learning by adapting educational content to students' needs and providing real-time feedback. Lasso-Rodríguez and Gil-Herrera (2020) explored the integration of eye-tracking, facial recognition, and machine learning with RPA. Their system dynamically adapted instructional content based on students' attention patterns, validating the feasibility of AI-driven personalization. Vulpe and Enăchescu (2022b) investigated how RPA could automate business processes within learning tasks. Using UiPath in interactive simulations, students engaged in early computational thinking and problem-solving activities, showing measurable improvements in engagement. Madaev et al. (2023) analyzed NAO and Pepper robots in classroom settings. These robots supported administrative tasks (e.g., grading, attendance) while tailoring content delivery to student needs and generating individualized reports. Lasso-Rodríguez and Gil-Herrera (2020) also piloted Aileen, an RPA-powered assistant that monitored students' cognitive states using facial recognition, EEG, and eye-tracking. Iterative pilot testing confirmed its capacity to adjust teaching strategies in real time.

Across these initiatives, the reviewed studies consistently report advantages of RPA-driven personalized learning, including:

- Reduction of administrative workload for educators.
- Real-time adaptation of instructional content.
- Early identification of academic needs and gaps.
- Exposure of students to computational and STEM-related skills.

At the same time, the studies highlight challenges, such as:

- High infrastructure and cost requirements.
- Concerns about student data privacy.
- Limited teacher expertise in automation technologies.

Evaluation and analysis of student behavior

Several studies examined how RPA supports the evaluation and monitoring of student behavior by automating repetitive assessment processes, analyzing learning patterns, and enabling personalized interventions. Hu et al. (2024) investigated the use of RPA within a Learning Management System (LMS) to process student assignments and monitor performance. The system validated submissions against predefined criteria, generated error-specific recommendations, and provided timely, data-driven feedback, significantly reducing administrative workload and bias. Their study adopted a diagnostic phase, workflow design, controlled pilot testing, and teacher training, confirming that iterative RPA integration improved grading consistency, supported self-directed learning, and enhanced instructional efficiency.

The reviewed studies identified key advantages of RPA in student behavior analysis:

- Enhanced evaluation accuracy and grading consistency, reducing bias and human error.
- Timely delivery of personalized feedback.
- Reduction of teachers' workload, allowing greater focus on pedagogy.
- Early identification of learning gaps, enabling targeted interventions.

At the same time, they reported challenges limiting adoption:

- Dependence on advanced infrastructure is often unaffordable in underfunded contexts.
- Lack of integration with AI-driven analytics for higher-order skills, such as critical thinking.
- Teachers need technical training to operate RPA effectively.
- Ethical concerns regarding student monitoring, especially risks of over-surveillance and data misuse (Madaev et al., 2023).

Support in experiential and simulated learning environments

Qasrawi et al. (2020) explored the applications of RPA in serious educational games, developing an automated analytical model that tracks student progress using player-generated data. This model replaces traditional pre- and post-test assessments with a continuous, automated evaluation system that analyzes students' skills, attention, and comprehension based on their in-game interactions.

The system functioned by collecting real-time player data, such as response times, movement patterns, and error frequencies, through RPA bots integrated with analytical tools. These data points were processed and analyzed using predictive models, generating instant feedback for students and educators.

The implementation process consisted of three key components: (1) an educational game developed using Unity 3D; (2) integration of RPA bots for real-time data collection; and (3) pilot tests with eighth-grade students. Results showed significant improvements: student success rates increased from 60% to 76.8%, while error rates decreased from 40% to 23.2%. Teachers also reported benefits from more precise evaluation tools, which enabled them to tailor personalized learning interventions.

These findings highlight the key benefits of RPA in experiential and simulated learning, including enhanced cognitive skill development, real-time feedback for adaptive learning, and increased student motivation due to the use of gamified environments.

Optimization of teacher time

Several studies highlight the role of RPA in reducing teachers' administrative workload by automating repetitive tasks such as attendance tracking, report generation, and assignment validation.

Phakdee et al. (2023) developed an RPA-based system using UiPath to validate student reports, automating error detection, providing instant feedback, and correcting vocabulary mistakes. Their system reduced processing time from 30 minutes to just 0.42 minutes, achieving a 97.34% error elimination rate and significantly enhancing assessment accuracy. Adoption by educators was reported as highly successful, demonstrating the practicality of structured training in automation technologies.

Mamidyala and Balusu (2024) introduced an AI-enhanced assistant bot integrated into a Learning Management System (LMS) to automate task evaluation and feedback delivery. This tool reduced grading workload, facilitated personalized feedback, and improved the quality of teacher–student interactions.

Munawar (2021) designed an RPA-integrated system tailored for Moodle, which streamlined administrative tasks such as attendance monitoring, quiz supervision, and task submission management. The implementation resulted in a 444% increase in operational efficiency compared to manual methods, underscoring the transformative potential of RPA in supporting instructional continuity.

Similarly, Zahurin et al. (2024) investigated the use of Microsoft Power Automate and Zapier in both public and private institutions. Their study reported a 73.4% increase in administrative efficiency and improved teacher satisfaction, as educators redirected time from routine tasks to student-centered activities and pedagogical planning.

Finally, Lasso-Rodríguez and Gil-Herrera (2020) applied RPA in teacher training environments through interactive videoconferencing. Their system automated the distribution of instructional materials and provision of real-time feedback, while also facilitating professional development, particularly in geographically constrained contexts.

Ethical, institutional, and contextual considerations

Although only a few studies explicitly addressed ethical, institutional, and contextual challenges, their insights highlight critical concerns such as data privacy, accountability in algorithmic decision-making, and the risks of over-reliance on automation (Gunawan & Wijaya, 2023; Mamidyala & Balusu, 2024). This limited but significant evidence suggests that while such considerations are underexplored in the current literature, they are nonetheless central to ensuring the responsible and sustainable integration of RPA into education systems.

Institutional and contextual barriers have also emerged in several studies. For example, Zahurin et al. (2024) identify a lack of digital infrastructure and staff resistance as significant obstacles to the deployment of RPA in schools. In this context, digital infrastructure encompasses not only technological tools but also reliable internet connectivity, adequate hardware, system integration, and the institutional capacity to manage cloud-based solutions. Similarly, Moşteanu (2022) and Turcu and Turcu (2021) emphasize the uneven adoption of RPA across countries and institutions, with more digitally mature environments showing greater integration capacity. Yet, the absence of large-scale comparative analyses remains a gap: most studies are limited to single-country or institutional case studies. This highlights the importance of future research to investigate cross-contextual factors, including national policy, training ecosystems, and budgetary constraints, in shaping the scalability of RPA in education.

The reviewed studies confirm that RPA plays a crucial role in automating educational processes, particularly in reducing teacher workload and enhancing grading efficiency through the automation of

repetitive tasks (Heins & Grunwald, 2024; Phakdee et al., 2023). Some studies further report that when RPA is integrated with adaptive analytics or AI-driven systems, it can support more personalized learning pathways by automating feedback loops and enabling real-time data collection on student performance (Lasso-Rodríguez & Gil-Herrera, 2019a; Moşteanu, 2022). However, the evidence for such pedagogical uses remains limited compared to the stronger research base on administrative efficiency. Experiential and simulation-based learning, in particular, is represented by only isolated cases (Qasrawi et al., 2020), highlighting the need for future research to examine how RPA can complement other digital technologies to enhance adaptive and student-centered learning environments.

RQ2: What Challenges Do Contemporary Studies on RPA in Education Face?

Despite its benefits, implementing RPA in education presents significant challenges. From a technical perspective, several studies highlight the difficulty of integrating RPA into existing learning management systems (LMS), which often require extensive customization, adjustments to interoperability, and teacher training (Hu et al., 2024; Zahurin et al., 2024). Pedagogical limitations also persist: RPA tools are effective for structured and repetitive tasks, such as grading multiple-choice questions or generating reports, but struggle with more complex tasks, including evaluating open-ended responses, creativity, or higher-order skills (Gunawan & Wijaya, 2023). At the institutional level, barriers include staff resistance to automation, lack of digital infrastructure, and insufficient resources to support large-scale deployment (Moşteanu, 2022; Turcu & Turcu, 2021). Collectively, these findings suggest that while RPA holds promise for improving efficiency, its adoption in education is constrained by contextual and technical barriers that limit scalability and pedagogical breadth.

Several studies indicate that the challenges associated with RPA adoption are closely tied to broader digital transformation processes in education. Zahurin et al. (2024) emphasize that insufficient infrastructure and limited institutional readiness constrain implementation, while Moşteanu (2022) and Turcu and Turcu (2021) highlight how uneven levels of digital maturity across institutions affect integration capacity. In this sense, successful RPA deployment depends not only on the availability of automation tools but also on interoperable systems, educator training, and supportive institutional frameworks. These findings suggest that RPA implementation should be understood as part of a wider digital transformation process that requires coordinated efforts in technology, policy, and professional development.

RQ3: What Gaps Exist in the Literature on RPA in Education That Justify Further Investigation?

While RPA research in education has predominantly focused on operational efficiency, three critical gaps emerge from the reviewed studies. First, the pedagogical impact of RPA remains underexplored: although several studies report benefits in administrative automation, only a few investigate direct effects on student learning outcomes or engagement (e.g., Hu et al., 2024; Lasso-Rodríguez & Gil-Herrera, 2019b), leaving open the question of how automation reshapes pedagogy. Second, issues of scalability and sustainability are insufficiently addressed. Most contributions are limited to small-scale or single-institution case studies (Turcu & Turcu, 2021; Zahurin et al., 2024), with little evidence on how RPA can be cost-effectively expanded across diverse educational settings. Third, the integration of RPA with AI and emerging technologies has been noted only in isolated studies (Moşteanu, 2022), which explore combinations with adaptive analytics or machine learning models. Collectively, these findings confirm that while RPA has demonstrated efficiency gains, its pedagogical, systemic, and technological implications remain fertile ground for future research.

Two articles (Liu & Ishak, 2023; Vulpe & Enăchescu, 2022b) propose that future research should examine hybrid models in which RPA and AI are combined. In this approach, RPA automates repetitive tasks such as data collection, grading, and reporting, while AI-driven systems analyze student performance, adapt learning materials, or provide predictive feedback. Together, these technologies

could create more personalized learning experiences for students and streamline educational work-flows for educators. Although still at a conceptual stage, these proposals highlight the potential of integrating RPA with AI to move beyond efficiency gains toward pedagogical innovation.

The reviewed studies confirm that RPA significantly enhances efficiency, accuracy, and automation in education. However, existing literature lacks comprehensive analyses of its long-term pedagogical impact and ethical considerations. Future research should prioritize pedagogical integration, cross-platform scalability, and ethical frameworks to ensure sustainable and responsible adoption.

While the inclusion of 17 empirical studies provides valuable insights, we acknowledge that the limited sample size constrains the generalizability of the findings across all educational settings. Nonetheless, the recurrence of certain themes across diverse institutions, countries, and educational levels suggests the presence of emerging patterns that merit further exploration. To strengthen these findings, future research should employ broader cross-regional analyses and longitudinal designs to validate and expand on these results.

DISCUSSION

The increasing complexity of modern educational environments has amplified the need for efficient, data-driven, and personalized learning experiences. RPA is emerging as a key enabler in transforming pedagogical practices by automating repetitive tasks, enhancing student engagement, and facilitating real-time decision-making for educators.

The systematic literature review, conducted through a structured methodological approach, identified five key use cases of RPA in the educational domain: Automation of Assessment and Feedback, Personalized Learning, Evaluation and Analysis of Student Behavior, Support in Experiential and Simulated Learning Environments, and Optimization of Teacher Time. These applications illustrate how RPA extends beyond administrative automation to become a driver of pedagogical innovation.

Prior research has demonstrated the role of automation in reducing instructor workload, improving grading consistency, and facilitating real-time feedback (Younis et al., 2023). However, these studies have primarily focused on administrative efficiencies rather than the pedagogical implications of automation.

This review expands prior perspectives by demonstrating that RPA not only automates assessment and administrative tasks but also supports evidence-based pedagogical innovation. For example, the ability of RPA to deliver real-time feedback strengthens formative assessment practices, while its role in data-driven personalization opens possibilities for adaptive learning pathways that adjust to students' needs. Moreover, by integrating RPA into decision-making processes, educators gain new opportunities to balance administrative efficiency with student-centered teaching. These implications indicate that RPA adoption has the potential to transform educational practices beyond operational gains, positioning it as a catalyst for pedagogical redesign and institutional innovation.

Despite these advantages, gaps remain in understanding RPA's impact on student engagement, knowledge retention, and the personalization of learning experiences. This review addresses these gaps by illustrating how RPA supports adaptive teaching strategies, enabling educators to make evidence-based pedagogical decisions while ensuring that students receive timely and tailored support.

AUTOMATION OF ASSESSMENT AND FEEDBACK

The findings confirm that RPA in assessment extends beyond efficiency gains: it is a catalyst for rethinking how evaluation can support adaptive and data-driven learning environments. By reducing repetitive tasks, RPA enables educators to redirect time and energy toward higher-order pedagogical strategies and student-centered engagement.

However, the persistent challenges – limited infrastructure, resistance among educators, and the inability to fully automate open-ended tasks – emphasize that adoption is not purely technical. Sustainable implementation requires institutional readiness, professional development, and alignment with educational goals. RPA should therefore be understood as a complementary tool, augmenting rather than replacing human judgment in assessment.

Strategic actions are necessary to unlock this potential. Teacher training is essential to build confidence and competence in integrating RPA into assessment practices. Interdisciplinary collaboration between educators and technology developers can help ensure that RPA-based solutions remain pedagogically relevant and context-sensitive. Clear institutional policies are also needed to align automation with ethical and pedagogical principles, ensuring transparency, accountability, and equity in data use.

Looking ahead, future research should examine hybrid models where RPA integrates with AI-driven analytics, particularly natural language processing (NLP), to extend automation into complex domains such as creativity, critical thinking, and problem-solving. Such advances would allow assessment systems to move beyond efficiency, fostering inclusive, adaptive, and evidence-based learning ecosystems.

PERSONALIZED LEARNING

The evidence confirms that RPA contributes to personalization by automating feedback and adapting instructional pathways. However, its impact remains nascent and fragmented. While multiple tools (e.g., HRI, robotic assistants, and simulation environments) demonstrate potential, they largely operate as prototypes or pilots, rather than scalable solutions.

A key insight is that personalization through RPA still depends heavily on the integration of complementary AI technologies (e.g., facial recognition, EEG monitoring, natural language processing). This suggests that RPA alone cannot deliver adaptive learning; instead, it functions as an enabling layer within hybrid AI-driven ecosystems.

Another critical point is equity of access. Most empirical applications are tested in digitally advanced or well-funded contexts, which raises questions about transferability to under-resourced educational systems. Without addressing infrastructure gaps and teacher training, the promise of real-time personalized learning will remain confined to select environments.

Ethical concerns further complicate implementation. Automated monitoring of students' biometric and behavioral data introduces risks related to privacy, consent, and algorithmic bias. This highlights the urgency of establishing institutional policies and regulatory frameworks to ensure that personalization enhances rather than undermines educational equity.

Overall, these findings suggest that while RPA-driven personalization enhances efficiency and adaptability, its pedagogical contribution is best understood as supportive rather than transformative at this stage. Future research should prioritize expanding longitudinal evaluations across diverse contexts, investigating the integration of RPA with emerging AI methods for adaptive learning, and developing frameworks that align personalization technologies with ethical and inclusive educational practices.

EVALUATION AND ANALYSIS OF STUDENT BEHAVIOR

The findings suggest that RPA has clear potential to strengthen the efficiency and objectivity of student behavior assessment. Automated grading and feedback reduce bias, while workflow-based implementations provide scalable models for institutional use. However, the evidence also underscores that these systems remain technically narrow: they excel at structured tasks (e.g., quizzes, assignments) but are not yet capable of handling open-ended or higher-order cognitive evaluations.

A broader implication is that RPA-driven student monitoring sits at the intersection of pedagogy and ethics. On one hand, automated detection of learning gaps enables early interventions and supports adaptive learning. On the other hand, pervasive monitoring raises concerns about student surveillance and a loss of trust. Without clear governance and safeguards, the promise of personalization may come at the cost of student privacy and autonomy.

Another key limitation lies in equity and transferability. Current applications are mostly tested in well-resourced environments with adequate infrastructure. In underfunded settings, the cost and technical demands of RPA could exacerbate digital divides, rather than close them. This highlights the need for supportive institutional frameworks, funding strategies, and capacity-building programs to ensure inclusive adoption.

Overall, the evidence suggests that while RPA contributes to improved efficiency and the early identification of student needs, its role in supporting pedagogical innovation depends on its integration with AI analytics and the establishment of ethical and inclusive policies. Future research should explore hybrid systems that combine RPA with natural language processing and learning analytics to assess complex skills, alongside longitudinal studies that evaluate the learning impact over time.

SUPPORT IN EXPERIENTIAL AND SIMULATED LEARNING ENVIRONMENTS

The reviewed evidence suggests that experiential and simulated learning remains one of the least explored areas of RPA adoption, despite its demonstrated potential to enhance cognitive skill development and engagement. The positive outcomes reported by Qasrawi et al. (2020) underscore the promise of immersive, gamified environments; however, limitations such as the small sample size (15 students), technical barriers in integrating RPA with Unity 3D, and the absence of a long-term evaluation constrain the generalizability of the current findings.

Additionally, integrating RPA with AI-driven analytics could personalize adaptive learning pathways in real time, while the convergence with emerging technologies (such as augmented reality (AR), virtual reality (VR), and adaptive learning platforms) may foster more immersive and student-centered ecosystems. In this sense, experiential learning provides a fertile ground to examine how RPA can bridge the gap between interactive engagement and data-driven decision-making, ultimately enhancing both cognitive and affective dimensions of learning.

OPTIMIZATION OF TEACHER TIME

The reviewed evidence demonstrates that RPA can substantially reduce teachers' administrative workload, freeing time for more pedagogically meaningful activities such as mentoring, curriculum design, and individualized student support. However, scaling these benefits requires careful consideration of institutional and systemic challenges.

First, persistent barriers remain:

- Resistance among educators is often linked to concerns over job displacement and the perceived complexity of automation.
- Inadequate IT infrastructure, which is particularly problematic in underfunded institutions.
- Lack of structured teacher training is limiting the effective adoption of RPA tools.

These challenges are not isolated but reflect a deeper structural issue: the fragmentation of implementation strategies. Rather than treating infrastructure, training, and tool adoption as discrete problems, institutions should adopt systemic approaches that integrate capacity building, regulatory frameworks, and collaborative workflow design.

From a policy perspective, dedicated funding mechanisms are needed to sustain RPA integration over the long term. Regulations should also ensure data privacy, algorithmic transparency, and equitable access to automation technologies. Moreover, empowering teachers through structured, pedagogy-oriented training programs is key to fostering sustainable adoption.

Future research should prioritize longitudinal analyses to assess the long-term impact of RPA adoption on teacher engagement and student learning outcomes. Additionally, integrating RPA with AI-driven adaptive learning systems and automated tutoring platforms could further enhance decision-making, personalization, and scalability across educational contexts.

In summary, while RPA adoption clearly demonstrates efficiency gains, its pedagogical potential will only be fully realized if supported by systemic policy reform, adequate infrastructure, and sustained professional development.

ETHICAL CONCERNS

Although the benefits of RPA in education are increasingly recognized, several ethical challenges remain – these primarily concern data privacy, transparency, and algorithmic fairness. The integration of automation in education requires the collection of large volumes of sensitive student data, raising questions about protection, security, and informed consent. Multiple studies highlight these risks, noting that institutions must comply with existing regulatory frameworks such as the General Data Protection Regulation (GDPR) and the Family Educational Rights and Privacy Act (FERPA) to safeguard student information (Lasso-Rodríguez & Gil-Herrera, 2020; Moșteanu, 2022; Zahurin et al., 2024). Transparent policies and robust encryption mechanisms are necessary to prevent misuse of student records.

Another ethical concern relates to algorithmic bias and fairness. When combined with AI-driven analytics, RPA systems may inadvertently replicate or reinforce inequities in assessment and feedback. For example, if automated grading models are not properly designed and audited, they may disproportionately disadvantage certain groups of students (Moșteanu, 2022). To mitigate these risks, institutions should conduct regular audits of automated processes and integrate explainable AI (XAI) methodologies to ensure accountability and transparency in algorithmic decision-making.

CONTEXTUAL AND IMPLEMENTATION BARRIERS

Beyond ethical issues, RPA adoption is constrained by contextual and implementation challenges. One recurring barrier is resistance among educators, who may perceive automation as a threat to job security or as a source of depersonalization of teaching. As Younis et al. (2023) notes, such resistance often arises from fears of job displacement, the complexity of integrating new tools into traditional workflows, and the lack of familiarity with automation technologies. Overcoming this barrier requires targeted professional development programs that enhance educators' digital literacy and demonstrate how RPA can complement, rather than replace, human-driven pedagogy.
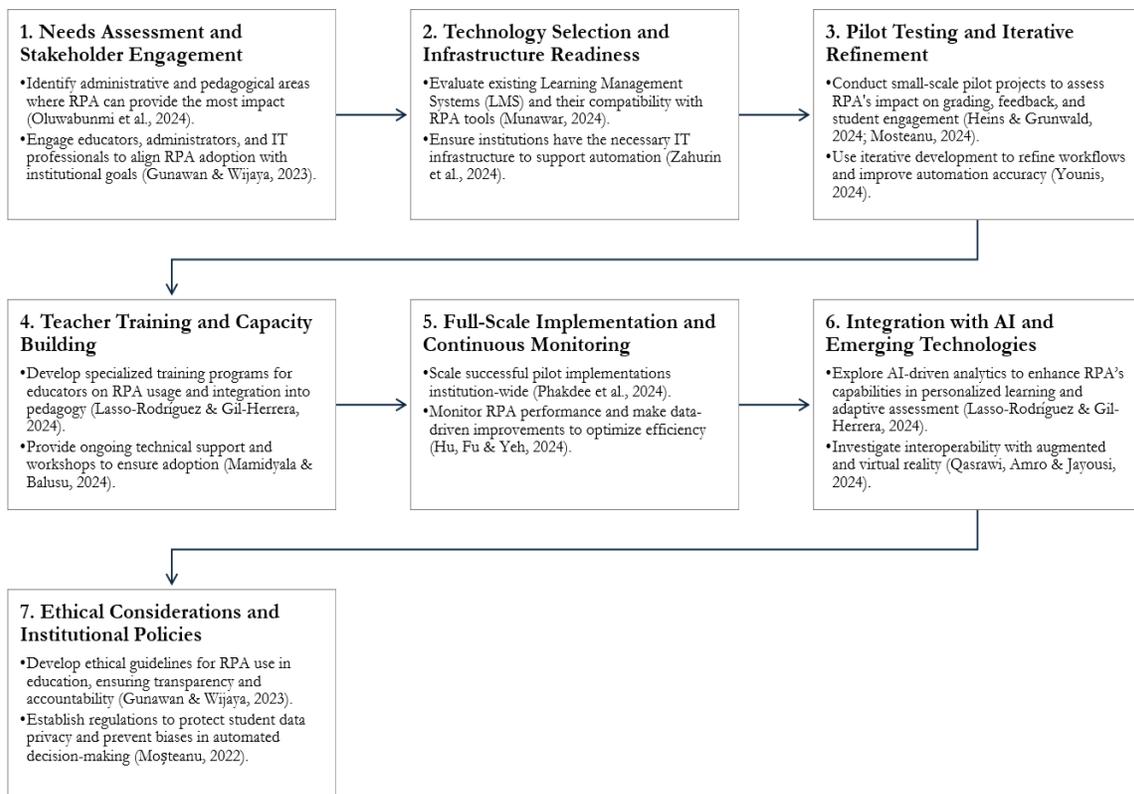
Another barrier is the cost of infrastructure and implementation. Research indicates that underfunded institutions often lack the necessary IT infrastructure and resources to integrate and maintain RPA systems effectively (Lasso-Rodríguez & Gil-Herrera, 2020. These challenges include not only financial investment but also reliable connectivity, adequate hardware, and ongoing technical support. Institutions may therefore require financial support mechanisms or subsidy programs to enable equitable adoption across diverse educational contexts.

To address these barriers, prior studies recommend three key actions. First, institutions should align their internal policies with existing regulatory frameworks (e.g., GDPR, FERPA) to ensure compliance with data protection and transparency requirements (Zahurin et al., 2024). Second, fostering interdisciplinary collaboration among educators, technologists, and policymakers is crucial for designing automation solutions that are both technically robust and pedagogically relevant (Lasso-Rodríguez & Gil-Herrera, 2020). Third, sustained investment in teacher training programs is necessary to build confidence and competence in the use of automation tools, ensuring that educators can effectively integrate RPA into their teaching practices (Younis et al., 2023). Finally, **improving** IT infrastructure remains a priority, particularly in under-resourced educational settings, to guarantee scalability and sustainable use of RPA systems (Moșteanu, 2022).

FRAMEWORK FOR IMPLEMENTING RPA IN EDUCATION

Figure 6 presents a framework for implementing RPA in education, which synthesizes recurring implementation stages identified across the 17 empirical studies included in this review. Each component of the framework is grounded in the literature: needs assessment and stakeholder engagement (Gunawan & Wijaya, 2023), infrastructure readiness (Zahurin et al., 2024), pilot testing (Heins & Grunwald, 2024; Moșteanu, 2022), teacher training and capacity building (Lasso-Rodríguez & Gil-Herrera, 2020), continuous monitoring (Hu et al., 2024), integration with AI and emerging technologies (Qasrawi et al., 2020), and ethical and institutional alignment (Mamidyala & Balusu, 2024).

Thus, the framework represents a structured synthesis of evidence from prior research, providing a stepwise guide to support the adoption of sustainable and responsible RPA in education. By following this structured framework, educational institutions can maximize the benefits of RPA while addressing potential challenges, ensuring a smooth and effective integration of automation in learning environments.

1. Needs Assessment and Stakeholder Engagement
- Identify administrative and pedagogical areas where RPA can provide the most impact (Oluwabunmi et al., 2024).
- Engage educators, administrators, and IT professionals to align RPA adoption with institutional goals (Gunawan & Wijaya, 2023).

2. Technology Selection and Infrastructure Readiness
- Evaluate existing Learning Management Systems (LMS) and their compatibility with RPA tools (Munawar, 2024).
- Ensure institutions have the necessary IT infrastructure to support automation (Zahurin et al., 2024).

3. Pilot Testing and Iterative Refinement
- Conduct small-scale pilot projects to assess RPA's impact on grading, feedback, and student engagement (Heins & Grunwald, 2024; Mosteanu, 2024).
- Use iterative development to refine workflows and improve automation accuracy (Younis, 2024).

4. Teacher Training and Capacity Building
- Develop specialized training programs for educators on RPA usage and integration into pedagogy (Lasso-Rodríguez & Gil-Herrera, 2024).
- Provide ongoing technical support and workshops to ensure adoption (Mamidyala & Balusu, 2024).

5. Full-Scale Implementation and Continuous Monitoring
- Scale successful pilot implementations institution-wide (Phakdee et al., 2024).
- Monitor RPA performance and make data-driven improvements to optimize efficiency (Hu, Fu & Yeh, 2024).

6. Integration with AI and Emerging Technologies
- Explore AI-driven analytics to enhance RPA's capabilities in personalized learning and adaptive assessment (Lasso-Rodríguez & Gil-Herrera, 2024).
- Investigate interoperability with augmented and virtual reality (Qasrawi, Amro & Jayousi, 2024).

7. Ethical Considerations and Institutional Policies
- Develop ethical guidelines for RPA use in education, ensuring transparency and accountability (Gunawan & Wijaya, 2023).
- Establish regulations to protect student data privacy and prevent biases in automated decision-making (Moșteanu, 2022).

Figure 6. Framework for the implementation of RPA in education

COMPARING RPA WITH TRADITIONAL EDUCATIONAL METHODS

To fully understand the impact of RPA in education, it is crucial to compare its functionality with traditional educational methods. Table 2 presents a comparative analysis of key aspects such as assessment, feedback delivery, administrative tasks, personalized learning, and student engagement.

This comparison highlights how RPA enhances traditional education by reducing inefficiencies and enabling data-driven, student-centered learning experiences. While traditional methods emphasize human interaction and critical thinking (Vulpe & Enăchescu, 2022a), RPA introduces adaptive learning pathways, improving engagement and instructional efficiency. However, RPA should not replace

human-driven pedagogy. Instead, it should be viewed as a complementary tool that enhances teaching effectiveness by automating repetitive tasks, allowing educators to focus on strategic and personalized learning interventions. By integrating RPA thoughtfully within education, institutions can foster more efficient, engaging, and personalized learning environments, enhancing both teaching effectiveness and student outcomes.

Table 2. Comparison between traditional educational methods and RPA-enhanced methods

Feature	Traditional methods	RPA-enhanced methods	References
Assessment	Manual grading, prone to subjectivity	Automated grading with high accuracy	Heins and Grunwald (2024); Moşteanu (2022)
Feedback delivery	Delayed due to teacher workload	Immediate feedback for real-time learning	Younis et al. (2023); Madaev et al. (2023)
Administrative tasks	High workload for educators	Automated workflows reduce administrative burden	Zahurin et al. (2024); Lasso-Rodríguez and Gil-Herrera (2020
Personalized learning	Standardized instruction for all students	Adaptive content based on student progress	Vulpe and Enăchescu (2022a); Lasso-Rodríguez and Gil-Herrera (2020)
Student engagement	Limited real-time interaction	Dynamic learning through automation and interactivity	Younis et al. (2023); Moşteanu (2022)

This comparison highlights how RPA enhances traditional education by reducing inefficiencies and enabling data-driven, student-centered learning experiences. While traditional methods emphasize human interaction and critical thinking (Vulpe & Enăchescu, 2022b), RPA introduces adaptive learning pathways, improving engagement and instructional efficiency. However, RPA should not replace human-driven pedagogy. Instead, it should be viewed as a complementary tool that enhances teaching effectiveness by automating repetitive tasks, allowing educators to focus on strategic and personalized learning interventions. By integrating RPA thoughtfully within education, institutions can foster more efficient, engaging, and personalized learning environments, enhancing both teaching effectiveness and student outcomes.

CONCLUSIONS

This research provides a comprehensive synthesis of how Robotic Process Automation (RPA) contributes to enhancing teaching and learning practices across various educational contexts. Evidence from the reviewed studies shows that RPA has been effectively implemented in areas such as personalized learning, automated feedback, and student behavior analysis, significantly optimizing teachers' time and enriching pedagogical experiences. By automating repetitive and administrative tasks, RPA enables educators to focus on higher-order instructional activities that promote adaptive and student-centered learning. Nevertheless, challenges remain in integrating technology, automating complex pedagogical processes, and addressing the ethical implications associated with RPA adoption.

The findings confirm that RPA enhances educational efficiency by reducing administrative burdens, improving grading accuracy, and enabling real-time feedback mechanisms. Its integration into personalized learning environments supports adaptive teaching strategies that address individual learner needs, underscoring RPA's transformative role in modernizing education. However, barriers such as limited infrastructure, resistance to automation among educators, and the need for ethical safeguards must be overcome to maximize its impact. From a practical standpoint, successful implementation depends on ensuring that automation complements, rather than replaces, human-centered teaching.

Institutions seeking to adopt RPA should invest in teacher training to strengthen digital literacy and confidence in using automation tools. Collaboration among educators, technology developers, and policymakers is essential for creating scalable and pedagogically aligned RPA solutions. Ethical frameworks must also be established to govern data privacy, algorithmic fairness, and responsible use of automation in learning environments. Additionally, adequate infrastructure and integration with Learning Management Systems (LMS) are required to ensure equitable access across diverse educational contexts. Strategic prioritization of RPA applications, particularly in personalized learning, real-time feedback, and student behavior analysis, can maximize their potential to enrich educational experiences and free teachers' time for creative and analytical tasks.

Beyond the institutional level, RPA's societal impact is significant. By reducing teachers' workload, automation enables more inclusive and equitable pedagogical practices, particularly in under-resourced environments. In such contexts, RPA can help bridge gaps in instructional quality and learning support. Yet, its deployment must be approached with caution to avoid over-reliance on automation or the erosion of critical thinking and human interaction in education. Responsible implementation should ensure that automation enhances accessibility and engagement without diminishing the human dimension of learning.

The synthesis also acknowledges certain limitations. The review draws from 17 peer-reviewed studies published in English between 2019 and 2024, providing thematic saturation but not full global coverage. This linguistic and temporal scope may have excluded valuable insights from non-English-speaking regions. Nevertheless, the consistency of findings across diverse methodologies and educational contexts reinforces the robustness of the conclusions and provides a solid foundation for further exploration. Expanding the geographic, linguistic, and methodological range of future research will deepen the understanding of RPA's potential in education.

Future studies should advance this agenda by exploring five key directions: integration of RPA with AI-driven adaptive learning systems to enhance personalization; longitudinal assessments of long-term impacts on teachers and students; development of ethical and regulatory frameworks to ensure fairness and transparency; design of scalable and accessible automation models for low-resource settings; and investigation of institutional and cultural factors influencing adoption. Addressing these areas will strengthen both the pedagogical and ethical foundations of automation in education.

In summary, RPA stands as a transformative enabler of educational innovation when implemented thoughtfully and responsibly. Its capacity to improve efficiency, personalize instruction, and promote inclusive learning environments highlights its strategic value for modern education. By aligning automation with ethical and pedagogical priorities, institutions can cultivate learning ecosystems that are not only more efficient but also more engaging, adaptive, and equitable.

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APPENDIX

Literature review on the use of RPA in education: Applications, benefits, and recommendations

Use case	Paper title	Authors	Year	Link or DOI	University	Study objective	Benefits	Recommendations
Automation of Assessment and Feedback	BIM and IPA – Excerpt of an automated assessment system for an autodidactic teaching concept	Heins, C., & Grunwald, G.	2024	https://doi.org/10.22260/ISARC2024/0039	Jade University of Applied Sciences	Develop and implement an automated assessment system for university courses in Building Information Modeling (BIM) using RPA and Digital Process Automation (DPA). The system aims to evaluate students' modeling skills efficiently and provide immediate feedback to enhance learning quality while reducing educators' workload by automating repetitive tasks.	• Efficiency: Significant reduction in teachers' workload through BIM model evaluation automation. • Learning Enhancement: Immediate feedback fosters iterative corrections and improves student learning outcomes. • Precision: Automated validation ensures high accuracy in assessing technical standards. • Resource Optimization: Time and resources are saved through improved evaluation processes.	• Establish precise validation rules to reduce subjective interpretations. • Implement unsupervised bots to increase scalability and flexibility. • Integrate AI to enrich analysis and personalize feedback. • Expand the system to cover broader educational areas. • Optimize the user interface for improved usability and adaptability.
Automation of Assessment and Feedback	Machine learning and robotic process automation take higher education one step further	Moşteanu, N. R.	2022	https://www-webof-science-com.ezproxybib.pucp.edu.pe/wos/woscc/full-record/WOS:000775912300007	American University of Malta	Explore how Artificial Intelligence, Machine Learning, and RPA can optimize repetitive tasks and improve efficiency in student assessment, admissions, registration, and counseling processes in higher education.	• Efficiency Gains: Automation of grading reduces manual efforts and increases accuracy. • Enhanced Learning: Structured feedback systems improve students' understanding of course content. • Transparency: Objective processes ensure fairness. • Educator Focus: Freed from repetitive tasks, educators can concentrate on impactful student interactions.	• Evaluate the benefits, risks, and costs of implementing RPA to ensure feasibility. • Transform organizational culture by training educators, students, and administrative staff to embrace RPA. • Define precise grading criteria for transparent and effective automation. • Engage key departments for seamless integration during implementation. • Adopt a progressive approach starting with simulations and gradual scaling under constant monitoring. • Establish policies to mitigate risks, such as external system manipulation.
Automation of Assessment and Feedback	A systematic literature review on the applications of robots and natural language processing in education	Younis, H.A., Ruhaiyem, N.I.R., Ghaban, W., Gazem, N.A., & Nasser, M.	2023	https://doi.org/10.3390/electronics12132864	Universiti Sains Malaysia, University of Basrah, University of Tabuk, Taibah University	Conduct a systematic review of the literature on integrating educational robots, such as NAO, and Natural Language Processing (NLP) technologies into education. The study identifies applications, benefits, and challenges, offering guidance for researchers, educators, and developers to leverage these technologies for transforming education. It highlights the role of these technologies in enabling personalized instruction, fostering collaborative learning, and automating tasks like assessments, thus reducing teachers' administrative workload and promoting inclusive educational environments.	• Enhanced Instruction: Personalized instruction fosters communication and critical thinking skills. • Efficiency Gains: Automated grading and instant feedback save teachers time. • Language Skills Development: Enhanced language learning via NLP-driven conversations and adaptive content. • Inclusive Education: Promotes inclusivity by supporting diverse student needs and engagement.	• Foster collaboration between educators and robots for effective classroom integration. • Invest in cost-effective solutions with robust infrastructure support. • Design adaptive systems catering to diverse educational needs and contexts.
Personalized Learning	Advanced human-robot interaction for learning with robotic process automation	Lasso-Rodríguez, G., & Gil-Herrera, R.	2019	https://doi.org/10.21125/iceri.2019.1832	Universidad Americana de Europa	Explore the integration of advanced human-robot interaction (HRI) within education using RPA. The study investigates how advanced HRI capabilities, such as eye tracking, facial recognition, and machine learning, can enhance visual and verbal interaction between robots and students. It also examines the feasibility of implementing	• Enhanced Personalization: Integration of RPA with HRI capabilities improves individualized learning experiences. • Technological Advancements: Technologies such as eye tracking, facial recognition, and machine learning optimize the	• Promote research into HRI technologies for educational use. • Invest in cost-effective and scalable systems to enable broader adoption in educational institutions.

Transforming Teaching and Learning with Robotic Process Automation

Use case	Paper title	Authors	Year	Link or DOI	University	Study objective	Benefits	Recommendations
						these features in educational contexts and aims to establish practical guidelines for transforming teaching and learning processes. The goal is to leverage artificial intelligence and RPA to personalize and enrich the educational experience.	adaptation of educational content to students' needs. • Task Automation: RPA-enabled robots automate administrative tasks, freeing up educators' time for pedagogical activities.	• Design experiments to evaluate the long-term impact of robotic teaching tools.

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Personalized Learning	Education through transition between classicism and modernism using robotic process automation technology	Vulpe, M.-I., & Enăchescu, V.-A.	2023	https://doi.org/10.15405/epes.2304 5.56	Bucharest University of Economic Studies	Investigate how RPA can be introduced into early and secondary education to teach business analysis and logical reasoning skills from an early age. The study focuses on demonstrating how RPA tools enhance analytical competencies and prepare students for a future where automation technologies play a crucial role. Additionally, it emphasizes how integrating RPA into educational programs facilitates the teaching of complex concepts in an accessible, interactive, and effective manner, providing students with practical skills applicable both academically and professionally.	• Educational Management: RPA simplifies repetitive tasks such as student data processing and report preparation, enhancing efficiency. • Skill Development: RPA-based tools support the development of analytical and problem-solving skills in students from a young age. • Efficiency in Teaching: Reduces educators' administrative workload, allowing more focus on instructional quality.	• Expand programs to include diverse schools and educational contexts. • Integrate RPA with advanced technologies, such as artificial intelligence, to enhance personalized learning experiences. • Evaluate the long-term impact of RPA on learning outcomes and skill development.
Personalized Learning	Robotics and automation in education	Madaev, S. M., Turluev, R. R., & Batchaeva, Z. B.	2023	https://doi.org/doi.org/10.1051/shs conf/202317 201012	Kadyrov Chechen State University y North Caucasian State Academy	Explore how robotics and automation can improve learning outcomes, enhance efficiency in educational processes, and expand access to global educational opportunities. The study investigates the potential of robotics and automation in personalizing learning, automating administrative tasks, and fostering collaboration among teachers, students, and administrators. It also addresses risks such as privacy concerns and investment challenges, offering strategies for responsible integration into educational settings. The focus is on the impact of robotics on practical learning and how automation can free teachers' time for more personalized and student-centered activities.	• Administrative Efficiency: Automation significantly reduces the time spent on repetitive tasks like grading and report generation, optimizing teacher effort. • Personalized Learning: Robotic systems adapt to individual student needs, fostering more effective and tailored educational experiences. • Accessibility: Robotics enables students from diverse socioeconomic backgrounds to access advanced educational resources.	• Establish specialized training programs for educators and school administrators focused on using and managing robotic technologies. • Develop clear ethical frameworks to ensure the protection of student data. • Promote public-private partnerships to reduce initial implementation costs.
Personalized Learning	Robotic process automation applied to education: a new kind of robot teacher?	Lasso-Rodríguez, G., & Gil-Herrera, R.	2019	https://doi.org/10.21125/ic-eri.2019.0669	Universidad Americana de Europa	Demonstrate the potential of RPA in education through the development of a prototype robot called "Aileen." This prototype is designed to support teaching and learning processes by providing personalized, interactive, and continuous assistance to students. The study highlights RPA's relevance as a complementary tool for teaching activities, optimizing repetitive tasks and facilitating recursive learning. By automating tasks such as lesson delivery, student progress evaluation, and social interaction, the robot aims to enhance the educational experience in an innovative and scalable environment.	• Cost-Effective Solution: The Aileen robot reduces costs by not requiring specialized hardware compared to traditional physical robots. • Scalability: Aileen's functionality can be replicated across multiple educational settings, facilitating broader adoption and distribution. • Support for Repetitive Tasks: The robot automates repetitive educational activities such as lesson preparation and student progress evaluation, saving time for educators.	• Integrate advanced technologies like artificial intelligence to enhance the robot's capabilities and adaptability. • Develop training programs for educators focused on the use of educational robots and RPA tools. • Promote additional research to explore the long-term impact of these technologies on education.
Personalized Learning	Computer system based on robotic process automation for detect-	Guacales-Gualavisi, M., Salazar-Fierro, F., García-San-	2021	https://doi.org/doi.org/10.1007/978-3-030-68285-9_15	Politeknik Negeri Bandung	Implement a system based on RPA to monitor student performance, enabling early interventions and improving the detection of performance issues in an e-learning system.	• Automated Data Collection and Analysis: Streamlines the identification of low-performing students with greater speed and precision. • Reduction of Manual Tasks: Frees teachers and administrators from repetitive	• Expand the system's functionality to include additional indicators of academic performance and student well-being. • Keep the system updated with the latest educational technologies and methodologies.

Use case	Paper title	Authors	Year	Link or DOI	University	Study objective	Benefits	Recommendations
	ing low student performance	tillán, J., Arciniega-Hidrobo, S., & García-Santillán, I.					manual processes, allowing focus on pedagogical activities. • Early Intervention: Facilitates the implementation of targeted support strategies to improve the performance of identified students.	• Clearly establish and communicate student data protection policies.

Use case	Paper title	Authors	Year	Link or DOI	University	Study objective	Benefits	Recommendations
Evaluation and Analysis of Student Behavior	Developing an early-warning system through robotic process automation: Are intelligent tutoring robots as effective as human teachers	Hu, Y.-H., Fu, J. S., & Yeh, H.-C.	2024	https://doi.org/10.1080/10494820.2022.2160467	National Yunlin University of Science and Technology	To explore and develop the application of RPA in improving educational processes, particularly to automate administrative and assessment tasks in higher education. The study aims to optimize educators' time, enhance precision and consistency in repetitive activities such as assignment management and student performance tracking, and demonstrate how RPA reduces educators' workload, allowing them to focus on pedagogical tasks and provide faster and more accurate feedback to students.	• Time Reduction: RPA significantly decreased the time spent on evaluations and report generation. • Error Minimization: Reduction of human errors in administrative and assessment tasks. • Focus on Pedagogical Impact: Educators could prioritize high-impact pedagogical activities. • Real-Time Reporting: Students received real-time feedback, enhancing the learning process.	• Integrate Advanced Systems: Explore combining RPA with AI for more complex tasks. • Comparative Studies: Conduct comparative studies with other automation technologies to identify more effective solutions. • Broaden Scope: Extend automation to other educational areas, such as course management and school administration. • Enhance Accessibility: Design more intuitive interfaces to reduce technological barriers and ease adoption.
Support in Experiential and Simulated Learning Environments	Automatic analytics model for learning skills analysis using game player data and robotic process automation in a serious game for education	Qasrawi, R., Amro, M., & Jayousi, R.	2020	https://doi.org/10.1109/ICPET51420.2020.00026	Al-Quds University	To develop an automated analytics model using player data from a serious educational game, combining learning analytics and RPA. This model is designed to automatically analyze students' learning skills through their interactions with the game, replacing traditional pre-post-tests with fully automated tools for evaluation. The focus is on evaluating how RPA-based technologies can manage, clean, and analyze large datasets to provide detailed insights into cognitive and academic skills development. The study also demonstrates the efficiency of these tools in improving students' attention and understanding by integrating digital technologies into education.	• Automated Data Processing: RPA reduces the manual workload in data collection and evaluation. • Cognitive Skill Enhancement: Students' cognitive abilities improve through consistent feedback based on their in-game performance. • Higher Accuracy: Results show greater precision and success in tasks as students become familiar with the game environment.	• Expand Sample Size: Validate the model's effectiveness across different educational contexts. • Incorporate Advanced Analysis: Explore integrating inferential analysis to better understand factors impacting learning. • Use Artificial Intelligence: Integrate AI elements to further personalize the educational experience.
Optimization of Teacher Time	Adopted Acceptance Test-Driven Development (ATDD) to produce Robotic Process Automation (RPA) for reducing teaching workload	Phakdee, N., Sisomboon, W., & Arbking, J.	2023	https://doi.org/10.1109/APCC60132.2023.10460654	Universidad Burapha	To evaluate the feasibility and effectiveness of RPA tools and features in supporting teaching within the field of Information Technologies in higher education. This involves identifying suitable business processes, developing an RPA bot to automate repetitive tasks and reduce teachers' workload, and integrating acceptance test-driven development (ATDD) with RPA to optimize teaching processes and enable educators to devote more time to higher-value educational activities.	• Significant Time Savings: Automation reduced repetitive task execution time from over 30 minutes manually to an average of 0.42 minutes. • Error Elimination: Achieved a 97.34% error reduction by mitigating common fatigue-related mistakes. • Enhanced Delegation: The system enabled teachers to delegate routine tasks like vocabulary validation, freeing time for more impactful activities. • Efficient Feedback Delivery: Automated error reporting and communication with students improved feedback processes. • High Satisfaction Levels: 85% of teachers reported satisfaction with the automation, emphasizing its utility in specific tasks.	• Broaden Teacher Participation: Include educators from diverse institutions and educational levels to evaluate RPA's effectiveness on a larger scale. • Expand File Handling Capabilities: Support additional file types like images (.jpg) and spreadsheets (.xlsx) to broaden RPA applications. • Compare RPA Tools: Assess open-source and commercial RPA solutions to determine advantages in precision and scalability. • Integrate Advanced Features: Incorporate capabilities for more complex tasks and progress toward comprehensive integration with educational systems.

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							• Adaptability: The developed framework can be applied to other repetitive educational processes across institutions.	• Upgrade Software: Transition from UiPath Community Edition to enterprise versions or web-enabled tools for enhanced usability. • Continuous Feedback: Gather consistent user feedback to guide system improvements and adaptations. • Expand Use Cases: Replicate the model in various educational contexts, including primary and secondary education programs, to assess broader applicability.

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Optimization of Teacher Time	Faculty Assistant Bot-automation of administrative activities using robotic process automation	Mamidyala, D. P., & Balusu, N.	2024	https://doi.org/doi.org/10.11591/ijece.v14i6.pp6797-6806	Telangana University	The primary goal of this study is to evaluate the impact of implementing RPA in improving administrative and academic processes in higher education, specifically at Telangana University, India. The study seeks to automate repetitive tasks, such as accreditation data management and institutional reporting, to reduce manual workload, improve process precision, and allow educators to focus on higher-value pedagogical activities. This research highlights RPA as a transformative tool to optimize efficiency in educational institutions, addressing the growing demand for regulatory data and reporting in the education sector.	• Task Automation: RPA automated repetitive tasks like data collection and report generation, saving time and resources. • Error Reduction: Decreased human errors in data management and administrative processes. • Process Speed Improvement: Automated processes significantly enhanced operational speed in accreditation and reporting. • Focus on Strategic Activities: Enabled educators and administrators to concentrate on strategic and pedagogical tasks.	• Expand Automation Scope: Explore other institutional processes that could benefit from RPA, such as student management or course administration. • Integrate AI: Incorporate AI for predictive analysis and administrative process personalization. • User-Friendly Interfaces: Develop more intuitive interfaces to facilitate tool adoption by non-technical staff.
Optimization of Teacher Time	Bot to monitor student activities on e-learning system based on Robotic Process Automation (RPA)	Munawar, G.	2021	https://doi.org/10.33395/sinkron.v6i1.11128	Politeknik Negeri Bandung	To develop and implement an RPA-based bot to monitor student activities on the Moodle virtual learning system. The bot automates routine tasks traditionally performed manually by teachers, such as attendance tracking, assignment collection, quiz monitoring, and email notifications. The study evaluates the efficiency of execution time for these tasks compared to manual methods. It aims to demonstrate how RPA can reduce teachers' workloads, improve data handling accuracy, and enhance operational efficiency in educational settings. Furthermore, the study proposes these solutions as critical tools in modernizing education through automated technologies.	• Automated Processes: The bot automates tasks like attendance tracking, assignment collection, and quiz result compilation. • Efficiency Gains: Achieved a 444% average efficiency improvement in functional tests compared to manual task execution. • Effort Reduction: Automatically generated detailed activity reports for students, reducing teacher workload.	• Integrate AI: Incorporate artificial intelligence to enhance the bot's capabilities, such as predictive analysis and personalized learning. • Scalability Testing: Test the system in multiple courses and with a larger number of students to validate its scalability. • User-Friendly Interfaces: Design a more intuitive interface for teachers and administrators using the bot.
Optimization of Teacher Time	Research on the application and development of rpa in accounting higher vocational education: A Chinese perspective	Liu, X., & Ishak, N. N. B. M.	2023	https://doi.org/10.54097/ijeh.v10i2.11592	Malaysia University of Science and Technology	To explore the integration of RPA in vocational accounting education in China. The study examines how RPA can enhance students' organizational and communication skills, as well as provide practical experience in the use of automation and data management tools.	• Efficient Skill Development: RPA implementation allows students to perform complex accounting tasks and data management efficiently, fostering workplace-ready practical skills. • Error Reduction: RPA-based systems streamline traditional processes such as calculations and report generation, improving accuracy and minimizing human errors.	• Expand Curricula: Include communication and problem-solving skills alongside technical competencies in vocational education programs. • Industry Collaboration: Partner with technology firms to provide access to RPA tools and practical experiences for students. • Teacher Training: Develop training programs for educators focusing on emerging technologies like RPA and big data.

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							• Hands-on Experience: Introducing tools like financial robots gives students practical experience with advanced technologies aligned with industry demands.	
Optimization of Teacher Time	The influence of robotic process automation on the administrative workload of teachers	Zahurin, K., Mamat, N., Wan Ali, W. N. H., & Abas, H.	2024	https://doi.org/10.11113/oiji2024.12n1.296	Universiti Teknologi Malaysia	To examine the impact of RPA on teachers' administrative workload. The primary objective is to analyze how RPA integration can minimize repetitive tasks and optimize administrative processes, enabling educators to focus more on pedagogical activities and student-centered tasks. The study also investigates the effect of RPA adoption on job satisfaction and the challenges associated with implementing these technologies in educational contexts. It emphasizes the potential of RPA to improve efficiency, accuracy, and productivity, ultimately enhancing teachers' work experiences and educational quality.	• Reduced Administrative Burden: Automation of tasks like data entry, email management, and calendar updates reduces time spent on routine activities. • Improved Efficiency: Teachers reported higher efficiency in generating reports and managing repetitive tasks, leading to more accurate data. • Increased Interaction Time: Freed time allows educators to engage more with students and prepare meaningful pedagogical activities.	• Pilot Programs: Implement pilot projects to evaluate RPA's impact in different educational settings and levels. • Technical Training: Develop training strategies for teachers and administrators to facilitate a smooth transition to automation. • Address Privacy Concerns: Establish clear and transparent protocols to mitigate privacy and security risks associated with RPA adoption.
Use case	Paper title	Authors	Year	Link or DOI	University	Study objective	Benefits	Recommendations
Optimization of Teacher Time	Training the teachers with assistance of robotic process automation	Lasso-Rodríguez, G., & Gil-Herrera, R.	2020	https://doi.org/10.21125/inted.2020.2373	Universidad Americana de Europa	To investigate the use of RPA as a tool to assist in teacher training. The study aims to validate the effectiveness of RPA-based robots as personal trainers for educators, enhancing their professional development and fostering continuous learning. It explores RPA robots' potential for teaching relevant knowledge through virtual interactions, emphasizing their communication capabilities, desktop applications for explaining topics, and adaptability to offer lessons at flexible schedules. The study evaluates RPA's effectiveness in education, focusing on technological innovation as a means to support and transform teaching processes.	• Automation of Routine Tasks: RPA robots assist in organizing educational materials and scheduling training sessions. • Flexible Training Schedules: Robots offer adaptable lesson timings, allowing teachers to access training sessions according to their needs. • Real-Time Interaction: Robots interact directly with educators via tools like Skype, delivering real-time lessons, addressing queries, and sharing visual materials.	• Expanded Pilot Programs: Conduct broader pilot studies to assess robots' impact and acceptance across diverse educational settings. • Targeted Technical Training: Develop specific technical training programs to enable educators to leverage robots' capabilities in their daily activities. • Focus on Emotional Intelligence: Include modules on emotional intelligence and adaptability to enhance teacher-robot interaction efficiency.
Optimization of Teacher Time	Modeling the education of the future with the help of robotic process automation	Lasso-Rodríguez, G., & Gil-Herrera, R.	2022	https://doi.org/10.21125/iceri.2022.0823	Universidad Americana de Europa	To explore the integration of RPA in the educational sector. The study highlights how RPA can automate administrative and teaching tasks, such as grading, scheduling, and data management, allowing educators to focus on more strategic pedagogical activities. Furthermore, it emphasizes the potential of RPA to enhance institutional efficiency, transparency, and agility in data and process management, ultimately reducing costs. In the context of digital transformation and globalization, the paper positions RPA as an innovative solution to modernize education and provide students with a more personalized and effective learning experience.	• Task Automation: RPA handles tasks like grading, scheduling, and other administrative processes, enabling educators to concentrate on teaching and building stronger relationships with students. • Enhanced Communication: Automation improves the presentation of content, making it more engaging and fostering better communication between educators and students. • Institutional Efficiency: The implementation of RPA in educational institutions provides agility, transparency, and efficiency in data and process management.	• Policy Development: Establish policies that promote the adoption of RPA in the educational sector, ensuring alignment with institutional needs. • Infrastructure Support: Allocate resources to develop and maintain the necessary infrastructure for RPA solutions. • Cultural Shift: Encourage an institutional culture that values and adopts technological innovation in educational processes.

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