DOI: 10.14421/ijid.2024.4682 IJID (International Journal on Informatics for Development), *e-ISSN: 2549-7448*
Vol. 13, No. 2, December 2024, Pp. 504-516

Assessing AI Integration in Islamic Higher Education: A Mixed-Methods Fishbone Diagram Analysis

Aan Ansori*
Department of Informatics Engineering
UIN SMH Banten
Serang, Indonesia
aan.ansori@uinbanten.ac.id

Fitri Damyati
Department of Informatics Engineering
Universitas Tirtayasa
Serang, Indonesia
fitri.damyati@untira.ac.id

Syifa Amara Dhestyani
Department of Computer Engineering
Telkom University
Bandung, Indonesia
syifaamdh@student.telkomuniversity.ac.id

Article History
Received November 5th, 2024
Revised December 20th, 2024
Accepted January 27th, 2025
Published January, 2025

***Abstract*— The integration of Artificial Intelligence (AI) in higher education has shown significant potential to improve the efficiency and effectiveness of learning. The strategic implementation of AI in State Islamic Higher Education Institutions (Perguruan Tinggi Keagamaan Islam Negeri/ PTKIN) fosters innovative pedagogy and improved academic performance. This study employs the Fishbone Diagram approach to systematically analyze AI's impact on PTKIN's education, identifying key factors influencing implementation. The method employs a reverse-cause analysis, mapping factors contributing to a primary issue, and identifying underlying causes and sub-factors. Findings highlight the crucial roles of technological infrastructure, human resource readiness, supportive policies, adaptive curriculum design, and organizational culture. This study underscores the necessity of integrated AI adoption frameworks in Indonesian Islamic higher education, harmonizing technological advancement with Islamic pedagogical principles. This study offers a foundational framework guiding PTKIN in developing sustainable and ethical AI policies. Comprehensive AI policies and strategies are essential for PTKIN to harmonize innovation with Islamic principles.**

Keywords—Artificial Intelligence's adoption; Artificial Intelligence's impact; effectiveness of learning; efficiency of learning; ethical AI policies

1 INTRODUCTION

In an increasingly rapidly developing digital era, Artificial Intelligence (AI) has become one of the technological innovations that significantly influences various sectors, including education. AI holds substantial potential to optimize the learning process, expand access to education, and create more personalized and adaptive learning approaches. Indonesian State Islamic Religious Higher Education Institutions (PTKIN), which translates as "Perguruan Tinggi Keagamaan Islam Negeri" in Indonesian, are educational institutions under the supervision of the Ministry of Religious Affairs of the Republic of Indonesia. The judicious integration of AI in Islamic education necessitates a nuanced understanding of its potential benefits and challenges, ensuring congruence with Islamic pedagogical principles.

PTKIN's AI adoption entails interconnected challenges, necessitating synchronized development of technological infrastructure, human resources, and pedagogical strategies. Effective technology integration in religious education hinges on comprehensive policies, regulations, and ethical frameworks.

AI has created significant changes in the education sector worldwide [1]. This technology offers a variety of innovative solutions that can enhance the efficiency of the learning process, personalize education, and provide broader access for learners. The integration of AI in e-learning systems facilitates adaptive, student-centered educational experiences. For example, AI can assist lecturers and educators in analyzing student performance more comprehensively and providing personalized learning recommendations, allowing students to maximize their potential. This phenomenon also includes the application of AI for administrative tasks such as scheduling, automated evaluation, and faster feedback systems, enabling educational institutions to focus more on the quality of education.

Additionally, AI plays a role in helping students develop skills that are relevant to industry developments, particularly concerning technology understanding. In the context of Islamic higher education, especially in PTKIN, AI has the potential to integrate learning materials with modern approaches without neglecting the religious values that form the basis of the curriculum. This development facilitates PTKIN's strategic positioning within the global educational landscape, harmonizing competitiveness with Islamic distinctiveness.

Behind its potential, the application of AI in education also faces various challenges and issues. One of the main problems is the gap in infrastructure and technological resources. Disparities in digital infrastructure, including internet connectivity and technological resources, constrain AI integration in educational settings. Additionally, the readiness of human resources also poses a challenge. Not all lecturers or educators possess the necessary skills and knowledge to use and optimize AI effectively in the learning process.

Disparities in AI technology access contribute to unequal learning opportunities and compromised academic outcomes. Lastly, there are concerns that AI could reduce human interaction in the educational process, which is an essential component of learning and character development [2].

Policies and the ethics of AI applications are also important issues. In religious education environments such as PTKIN, the use of AI needs to be carefully considered to ensure it does not conflict with the Islamic values that serve as the foundation of education. Regulations related to student data privacy must also be well-defined, as the implementation of AI often involves extensive data collection. This raises concerns about data security and the potential for misuse.

The presence of AI in the educational environment of PTKIN brings significant changes to teaching patterns, administration, and learning. Personalized learning environments are facilitated through technology, optimizing educational outcomes. This has a positive impact as students in PTKIN, who come from diverse backgrounds and have varying needs, can receive learning that is more relevant and aligned with their potential. For example, AI can analyze students' academic data and provide appropriate and relevant learning content, allowing them to learn at their own pace and style. Through this approach, lecturers and institutions can offer more effective attention to the development of each student, facilitating deeper engagement in their educational process.

Additionally, the use of AI for automation in educational administration has helped PTKIN save time and costs in managing administrative tasks, such as academic data management, registration processes, and evaluation of learning outcomes. This study demonstrates how administrative automation fosters student-centered learning environments and pedagogical innovation. They can obtain quick answers to basic questions about course materials or campus policies without having to wait for class hours or meet directly with lecturers. This is particularly beneficial, especially in PTKINs with thousands of students and diverse learning needs.

The intersection of AI and Islamic values in PTKIN environments presents complex ethical and privacy challenges, demanding nuanced examination. The aggregation of student academic data precipitates concerns regarding data privacy, emphasizing the necessity for robust protection measures. Furthermore, there are concerns about the transparency of algorithms and the decisions made by AI, particularly in the evaluation of learning outcomes [3]. Maintaining ethical integrity in AI utilization is vital to harmonize technological innovation with Islamic educational values. Therefore, while AI presents many opportunities, PTKIN must ensure that its application is carried out responsibly and ethically, considering its impact on students and the educational environment [4].

Therefore, a comprehensive analysis is necessary to understand the impact of AI on PTKIN from various interrelated dimensions. This research employs the Fishbone Diagram approach as a tool to analyze the main causal factors influencing the implementation of AI in PTKIN. This qualitative inquiry adopts a holistic framework, incorporating six interrelated dimensions, to elucidate AI adoption dynamics within Indonesian Islamic higher education. The results of this analysis are expected to serve as a guideline for PTKIN in designing sustainable AI implementation strategies

that align with the principles of Islamic education and support the achievement of better educational quality in the future.

2 METHODS

Fishbone analysis is a method used to systematically and structurally identify the root causes of a problem [5]. This method helps in mapping out various factors that contribute to a main issue, to uncover the underlying causes. The process begins by identifying the main problem at the tail of the diagram and then outlining various related categories of causes. These categories are then analyzed to identify sub-factors that point to more specific causes, allowing for in-depth and focused analysis of each element influencing the problem. Where the problem is at the tail and the solution is directed toward the head, the same analytical structure is maintained while presenting the information in a different visual flow. Each category may have sub-factors that indicate more specific causes, allowing for an in-depth and focused analysis of each element influencing the problem [6].

2.1 Flowchart.

A flowchart is a visual representation used to depict the sequence of steps or processes in a workflow systematically and logically [7]. In a flowchart, each step or decision is represented by specific symbols, such as rectangles to indicate activities or tasks, diamonds to indicate decision points, and arrows to direct the flow from one step to the next. The application of flowcharts optimizes process visualization, thus facilitating interdisciplinary collaboration and informed decision-making.

To implement the fishbone diagram effectively, a systematic logical scheme is needed, where the cause-and-effect relationships between factors are organized into branches resembling fishbones [8]. This scheme not only aids in visualizing the complexity of the problem but also makes it easier for the team to understand the interconnections among factors, leading to more targeted solutions. By leveraging fishbone analysis, practitioners can systematically diagnose complex problems, yielding targeted interventions and enhanced solution efficacy [9]. The systematic application of the Fishbone Diagram is diagrammatically illustrated in Figure 1.

The explanation for each step from start to finish in Figure 1 is as follows. Problem identification in the context of the fishbone diagram is an essential first step to identify and define the issue to be analyzed [10]. This process involves gathering information about the symptoms that arise and the consequences of the problem, and classifying whether the problem is desirable or undesirable. Employing data analysis methodologies enables the systematic exploration and elucidation of latent factors influencing the current state. The goal is to ensure that all parties understand precisely what the main issue is so that appropriate solutions can be formulated and effectively implemented in the subsequent steps [11].

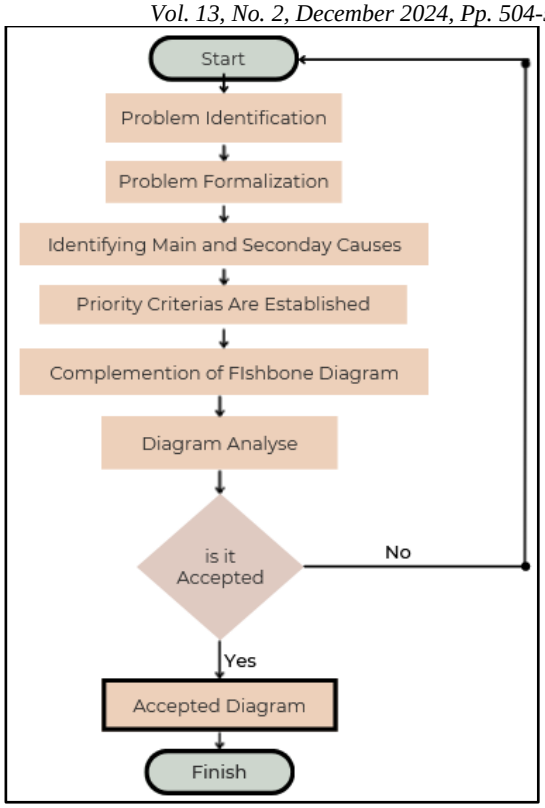

Figure 1. Logic scheme of fishbone diagram implementation

Problem formalization in the second stage of the fishbone diagram involves organizing and presenting the identified problem in a more structured and clear form. At this stage, the information obtained from the problem identification process, including data analysis from observations of operational workflows, is systematically organized to create a concise problem statement [12]. This formalization includes replacing ambiguous terms, such as 'ineffective communication,' with specific definitions, such as the absence of standardized protocols and delayed feedback. In addition, the key factors influencing the problem, such as resource constraints and misaligned priorities, are identified. This structured formalization not only facilitates better understanding among team members but also serves as a strong foundation for further analysis and the development of targeted solutions [13].

The third stage of the Fishbone Diagram methodology involves a nuanced distinction between primary and secondary causes, facilitating a comprehensive understanding of causal relationships [14]. Iterative analysis facilitates the decomposition of complex problems into primary and secondary causes. Grouping and categorization techniques facilitate a nuanced understanding of causal relationships, enabling the team to assess the impact and relevance of each factor [15]. Accurate causal diagnosis provides a foundational framework for crafting efficacious, precision solutions.

The Priority Criteria stage facilitates systematic evaluation and hierarchical ranking of causal factors [16]. At this stage, the team conducts an in-depth analysis of each identified cause, evaluating its relevance, frequency, and potential impact. Establishing priority criteria enhances

resource allocation efficiency and problem-resolution efficacy. This methodology enhances solution efficacy and sustainability, reducing recurrence probabilities [17].

Completing the Fishbone Diagram in the fifth stage is the final step where the team finalizes the diagram that has been created with all the identified and prioritized primary and secondary causes [18]. At this stage, the team ensures that all relevant elements have been included in the diagram and that it clearly illustrates the relationships between the core problem and the causes influencing it. The completed diagram undergoes rigorous evaluation to ensure accuracy and effectiveness, facilitating evidence-based solution development. If not, the process can be repeated to review and refine any inaccurate elements, resulting in a comprehensive and informative fishbone diagram, ready to be presented and used in the problem-solving process [19].

Diagram Analysis in the fifth stage of the Fishbone Diagram is the evaluation process conducted after the diagram has been constructed to ensure that all identified causes are relevant and accurate in the context of the issue being faced [20]. At this stage, the team analyzes the relationships between the primary and secondary causes and checks whether the diagram as a whole reflects a deep understanding of the issue being analyzed. This analysis also includes discussions among team members and, ideally, additional input from interviews and observations to gather diverse perspectives and ensure the diagram's reliability. If the diagram has been created without these crucial data-gathering processes, it may require significant adjustments or refinements to improve its validity. The goal is to produce a diagram that is not only informative but also reliable as a foundation for formulating effective solutions and action strategies to address the identified problem [21].

The Accepted Diagram phase signifies collective validation, ensuring the diagram accurately represents the problem's causal relationships [22]. At this stage, the team conducts a final verification to ensure that all elements, including the primary and secondary causes, have been correctly included and prioritized according to the previous analysis [23]. Team discussions, ideally incorporating input from all members, help confirm the diagram's accuracy and ensure consensus. If the diagram receives approval, it signifies that all parties have a shared understanding of the issue at hand, and the diagram can be used as an effective tool for formulating solutions and follow-up actions. The iterative refinement process ensures diagram validity and reliability.

2.2 Fishbone.

The Ishikawa Diagram, a seminal quality management framework, elucidates complex causal relationships [24]. Introduced by Kaoru Ishikawa in the 1960s, this diagram provides a systematic way to illustrate the relationship between the causes and effects of an issue. In its structure, the diagram resembles a fish skeleton, where the fish's head represents the problem to be solved, while the bones extending from the head depict the categories of causes contributing to the problem. These categories are often grouped into six categories known as the 6Ms: Manpower, Machinery, Methods, Materials, Measurement, and Mother Nature [25].

The research underscores the Fishbone Diagram's efficacy across education, manufacturing, and service sectors, enhancing root cause analysis. "Research employing the Fishbone Diagram can elucidate factors influencing AI integration within PTKIN institutions. By identifying various causes that may contribute to problems, educational institutions can formulate more effective strategies to enhance the quality of teaching and learning. The Fishbone Diagram's collaborative framework facilitates systematic identification and evaluation of latent causes.

The Fishbone Diagram offers a rigorous methodology for deconstructing complex problems. The Fishbone Diagram enables a nuanced understanding of multifaceted problems through visual representation. The research underscores the Fishbone Diagram's efficacy in quality management and process improvement applications. This method is widely used to identify the root causes of problems due to its ability to systematically map out factors that influence outcomes, such as through the 6M approach.

In Figure 2, the example of the figure caption illustrates the analysis using the 6M approach. Here is an explanation of each category:

2.2.1 *Manpower:* This factor includes all aspects related to human resources, including the skills, knowledge, and motivation of the workforce involved in the process [26]. Issues such as a lack of training or the inability to use new technology can affect the outcomes.

2.2.2 *Machinery:* This includes all equipment and technology used in the process. Unreliable machinery and frequent maintenance requirements can significantly impede operational efficiency. Poorly maintained machines can reduce work efficiency [27].

2.2.3 *Methods:* Method factor encompasses organizational protocols, policies and procedural workflows. Non-standard, ineffective, or poorly understood methods can lead to inconsistent results. Inefficient work processes can also impact productivity [28].

2.2.4 *Materials:* The materials or inputs used in the process are also important factors. Low-quality materials or those that do not meet specifications can affect the outcome. Additionally, the unstable availability of materials can also lead to disruptions in the process [29].

2.2.5 *Measurement:* Measurement includes the measuring tools and methods used to evaluate performance. Inaccurate measuring tools or incorrect measurement methods can produce erroneous data, which affects analysis and decision-making [30].

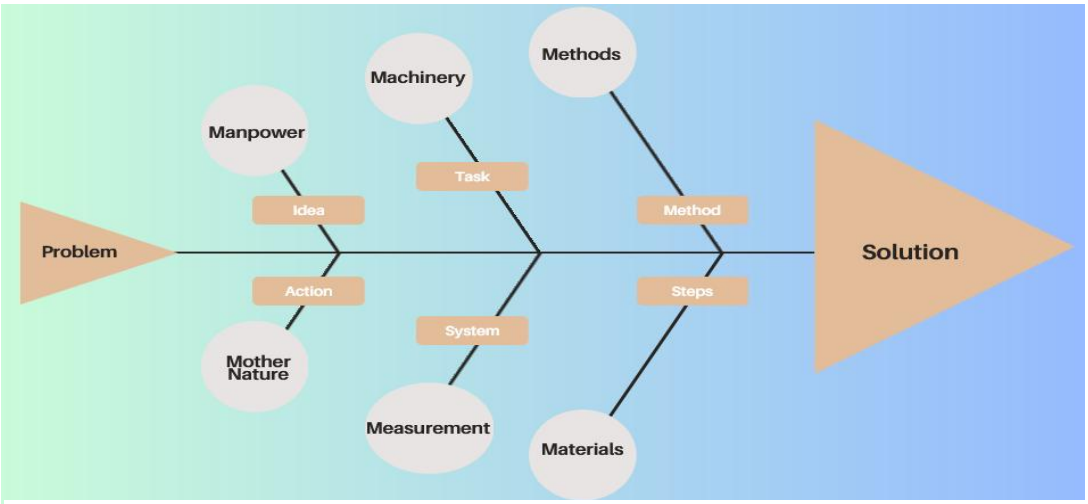

Figure 2. The example of the figure caption illustrations

2.2.6 *Mother Nature:* Environmental factors include external conditions that may affect the process, such as weather, temperature, or humidity. These factors can also encompass the influence of workplace culture, social environment, or regulatory changes that impact operations [31].

This diagram can help identify the sources of problems from various aspects to understand the root causes of an issue and take appropriate steps for improvement.

Here are the definitions of Idea, Task, Methods, Action, System, and Steps, which are the development of the 6M Fishbone concept. *An idea* is an initial idea or concept that emerges as a potential solution to existing problems or to improve ongoing processes [32]. These ideas typically arise from the analysis of categories such as manpower. *Tasks* are deliberate sequences of actions intended to realize predetermined objectives. Tasks are part of the implementation of identified ideas or solutions [33]. Each task is typically related to certain aspects, such as those concerning Machinery, which may include inspections or routine maintenance. *Methods* denote deliberate, structured procedures for achieving task objectives [34]. Methods encompass standard operating procedures, techniques, and protocols to ensure that all processes run according to plan. Methods serve as one of the categories for establishing a stable process. A good system must consider each category to ensure that all factors function harmoniously. *Action* refers to the concrete steps or measures taken to implement methods and complete tasks [35]. Action is the embodiment of the methods designed to achieve goals practically. Action is related to the elements of activity, typically in alignment with the surrounding environment. *System* refers to a collection of integrated procedures, equipment, resources, and personnel aimed at achieving specific outcomes [36]. The system is how all elements work together to achieve objectives. Corrective actions emerge from the synergistic integration of categorized interventions, addressing performance deficiencies identified through measurement. *Steps* refer to the specific sequence or stages required to complete a task or method [37]. Steps constitute discrete, chronological actions within a process framework. They are often organized in sections, such as the use of Machinery, and must be followed to minimize errors in operations.

3 RESULT AND DISCUSSION

The analysis using the Fishbone Diagram can assist stakeholders in PTKIN in formulating a holistic and integrated strategy for effectively implementing AI. This study employs mixed-methods research, incorporating stakeholder perspectives through interviews, focus groups, and surveys. This study employed methodological triangulation to integrate diverse perspectives and enhance analytical rigor. Documents such as meeting minutes, interview transcripts, and survey results are included in the appendix to support the involvement of all relevant stakeholders. These documents serve as evidence of the collaboration and participation of key parties, including academic staff, students, and institutional leaders, in the analysis and formulation of strategies for AI implementation at PTKIN.

The research employs Fishbone Diagrams to elucidate factors influencing AI integration in educational environments. This diagram helps identify the root causes and categorize various elements that contribute to the success or failure of AI technology adoption. This study employs a multidimensional framework to examine AI's integration in education, considering internal and external factors. Fishbone Diagram analysis provides actionable insights for AI implementation optimization, informing data-driven decision-making.

3.1 Fishbone Analysis.

This study adapts the Fishbone Diagram framework to PTKIN contexts, elucidating relationships between factors influencing educational outcomes. Government AI regulations inform curriculum integration, facilitating targeted educational strategies. Additionally, by understanding the interdependencies between these factors, PTKIN management can design more appropriate training programs for lecturers and teaching staff, and develop policies that support innovation in education. Thus, the Fishbone Diagram serves not only as an analytical tool but also as a strategic guide to ensure that the implementation of AI in PTKIN is conducted effectively, and efficiently, and aligns with the values upheld by religious educational institutions. For further explanation, please see Figure 3.

3.2 Technology

Sufficient technological infrastructure is crucial for the implementation of AI in education. Dependence on internet access and optimal hardware poses a major challenge for several PTKINs. Suboptimal infrastructure hinders AI-powered education initiatives. The research underscores the need for robust data protection protocols in AI-enhanced educational environments

3.2.1 *Data Security and Privacy:* This study investigates data privacy and security risks associated with AI adoption at PTKIN. With the increasing amount of data collected through e-learning systems, learning applications, and automated assessment tools, PTKIN needs to implement effective protection measures to prevent unauthorized access, data theft, and misuse of information. Clear policies related to data protection must be enforced, including data encryption, access controls, and audit procedures to ensure that personal data is secure from potential threats [40]. Additionally, awareness and training on best practices in cybersecurity should be provided to the entire academic community to maintain integrity and trust in the use of technology. This study emphasizes data security and privacy as pivotal factors in successful AI adoption within PTKIN's educational framework

3.2.2 *AI Software Resources:* Applications and platforms designed to leverage AI in supporting the educational process at PTKIN. This software includes adaptive e-learning systems that can adjust content and teaching methods according to individual student needs, chatbots that serve as virtual assistants to answer questions and provide academic support, and automated assessment tools that can evaluate student performance objectively and efficiently [39]. The availability of suitable and high-quality AI software is crucial for enhancing interactivity in learning, facilitating communication between lecturers and students, and optimizing the evaluation process. PTKIN must prioritize data security and privacy protocols when implementing educational software. With the appropriate selection and implementation of AI software, PTKIN can enhance the effectiveness of teaching and learning, and prepare students to face challenges in the increasingly evolving digital era.

3.2.3 *Technological Infrastructure:* Technological infrastructure is a crucial component in supporting the implementation of AI in PTKIN, which includes fast and stable internet access, adequate hardware, and the availability of relevant software, such as adaptive e-learning systems and automated assessment tools. Data security and student privacy are also important aspects, as concerns about the protection of personal information can hinder technology adoption [38]. Additionally, ongoing technical support and maintenance are necessary to ensure all systems function properly, while effective technology integration allows for the efficient use of AI in various aspects of education. By building a strong technological infrastructure, PTKIN can create a learning environment that fosters innovation and enhances the quality of education, preparing students to face challenges in an increasingly digital workforce.

3.3 Human Resources

Research indicates lecturer readiness as a pivotal factor influencing AI integration efficacy in educational contexts. The research underscores the importance of targeted training and professional development in facilitating successful AI adoption within higher education institutions. PTKIN requires AI expert involvement to ensure effective technology integration and educational optimization.

3.3.1 *Lecturer Readiness:* An important factor in supporting the implementation of AI in PTKIN, as lecturers play a central role in integrating this technology into the learning process. This study examines lecturers' readiness to integrate AI-driven technologies, focusing on technical competence and pedagogical adaptability [41]. Lecturers necessitate specialized training for effective integration and utilization of educational technology. Additionally, lecturer readiness is also related to an open attitude toward change and technological innovation in education, which can positively impact student engagement and overall learning outcomes. PTKIN's strategic investment in lecturer AI readiness enhances educational quality and institutional competitiveness.

3.3.2 *Training and Development:* Developing AI literacy among lecturers, staff, and students is crucial for successful educational technology integration. This training includes mastering AI software, understanding the ethics of technology usage, and acquiring other technical skills necessary for implementing adaptive learning systems, automated evaluation tools, and AI-based interactive platforms

[42]. In addition to enhancing technical abilities, this training also aims to change mindsets and attitudes toward technology, thereby encouraging better acceptance and adaptation to changes in the teaching and learning process. Ongoing development programs may include tiered training, workshops, and collaborations with AI experts to ensure a deep understanding and targeted application of AI. PTKIN's comprehensive training strategy fosters internal capacity, driving technological innovation and educational excellence.

3.3.3 *Role of Experts:* This study explores the impact of AI expert involvement on educational technology efficacy at PTKIN. Expert involvement is essential for effective AI implementation at PTKIN, ensuring optimal technology utilization. This study explores the role of AI experts in designing adaptive learning systems and automated evaluation tools, enhancing educational efficacy [43]. This study examines the impact of expert-led training on educator competence in AI-driven educational environments. With the presence of experts, PTKIN can accelerate the adoption of AI, minimize technical challenges or data security risks, and ensure that technology implementation is conducted ethically and efficiently. The involvement of experts also fosters the creation of innovations in the teaching and learning process, enhancing the quality of education and preparing students to face challenges in the digital world.

3.4 Policies

This study investigates government regulatory impacts on AI integration within Indonesian Islamic higher education, focusing on PTKIN. AI governance policies in Islamic education must integrate ethical, moral and spiritual considerations. Financial support from the government or related institutions is also essential to enhance AI adoption, ensuring that PTKIN has sufficient resources to invest in this technology.

3.4.1 *Government Regulations:* play a crucial role in regulating the application of AI at PTKIN, as these regulations provide clear guidelines and standards that institutions must adhere to when using the technology. These rules encompass aspects of protecting the personal data of students and faculty, system security requirements, and ethical limitations in the implementation of AI to ensure that technology aligns with religious values and national education policies [44]. Effective AI regulations ensure transparency, accountability and data protection in educational settings. Robust regulations enable PTKIN's confident AI adoption, minimizing legal liabilities and fostering stakeholder trust. Government regulations also encourage responsible innovation in the education sector, enabling the sustainable implementation of AI that maximizes benefits for all involved parties.

3.4.2 *Ethics and Morality:* The application of AI at PTKIN is an important aspect that ensures the use of technology remains aligned with religious values and moral principles upheld. As a religious educational institution, PTKIN needs to consider the ethical implications of AI, particularly regarding interactions with students, management of personal data, and the impact of technology on the learning process. AI ethics involves responsibilities for maintaining privacy, transparency in data usage, and fair treatment of all students [45]. This study highlights AI's limitations in replicating human educators' spiritual and emotional contributions. This study examines PTKIN's successful integration of AI-driven education within an Islamic ethical framework.

3.4.3 *Funding:* A fundamental factor in the implementation of AI at PTKIN, as this technology requires significant investment in infrastructure, training, and the development of adequate software and hardware. Financial support from the government, related institutions, or partnerships with the private sector is crucial to enable effective and sustainable AI adoption [46]. Sufficient funding allows PTKIN to provide fast internet access, modern hardware, and training for faculty and educational staff to be prepared to operate AI-based technology. Additionally, adequate funds are also necessary to build robust security systems to protect the data of students and faculty, and to ensure compliance with applicable regulations. With an appropriate allocation of funds, PTKIN can maximize the benefits of AI in improving the quality of education, supporting research, and enhancing the institution's competitiveness in facing the challenges of the digital era.

3.5 Curriculum

Research highlights the importance of integrating AI skills within educational frameworks to foster competencies. This study explores AI-driven personalized learning's impact on student achievement and satisfaction. Furthermore, AI-based learning assessments can provide more objective and accurate results in measuring student performance.

3.5.1 *Integration of AI in Courses:* An innovative step aimed at enriching the learning process and preparing students to face technological developments in the workforce. Integrating AI facilitates personalized learning experiences, leveraging simulations, data analysis and adaptive assessments [42]. For instance, in courses that require complex analysis, AI can assist students in recognizing patterns or completing data-based tasks more effectively. Research demonstrates that AI-based feedback systems improve student outcomes

and instructor responsiveness. However, to implement this, PTKIN needs to ensure infrastructure readiness and provide training for faculty so that AI can be harmoniously integrated with traditional teaching methods. This study examines AI integration's impact on educational outcomes and workforce preparedness.

3.5.2 *Personalized Learning Approach:* This study investigates AI-driven personalized learning's impact on student outcomes and satisfaction. In this approach, AI analyzes data such as learning outcomes, interaction patterns, and learning preferences to customize materials and teaching methods, allowing students to learn according to their styles and rhythms [47]. This approach enables the development of a more responsive and adaptive curriculum, which can help students gain a deeper understanding of the material and improve learning outcomes.

3.5.3 *AI-Based Learning Evaluation:* This assessment method utilizes artificial intelligence technology to analyze and evaluate students' learning outcomes objectively and efficiently [48]. This study explores AI-driven grading automation's impact on feedback quality, student satisfaction, and academic performance. Research indicates that AI-based learning analytics improves instructor responsiveness to student needs. AI-based evaluation enables the identification of areas needing improvement for each student, making the assessment more personalized and supporting learning development. In PTKIN, this system also has the potential to accelerate the evaluation process without compromising the quality of assessments, thereby supporting the improvement of educational quality.

3.6 Organizational Culture

This study examines the relationship between stakeholder attitudes and AI adoption outcomes in higher education. Changes in teaching methods brought about by AI may face resistance from some faculty or students. Therefore, management needs to be able to adapt the use of AI in the academic and operational systems of PTKIN, ensuring that all parties are involved and support this change.

3.6.1 *Acceptance of AI in Islamic Education:* presents challenges and opportunities, as this technology must be integrated in alignment with religious values [48]. An open attitude from faculty, staff, and students is crucial to support the implementation of AI, especially in assisting the teaching-learning process and managing administration more efficiently. Although AI can offer many benefits, such as personalized learning and automated assessments, the application of this technology must be carried out with careful consideration of the ethical and moral aspects of Islam. Integrating AI within faith-based education: Balancing technological innovation and spiritual integrity. Integrating AI within Islamic higher education: PTKIN's model for harmonizing faith and technology.

3.6.2 *Changes in Teaching Patterns:* The effects of implementing AI in PTKIN bring significant transformations in learning methods. With this technology, faculty can shift from traditional one-way approaches to more interactive and collaborative methods [48]. AI enables more personalized teaching, where materials are tailored to the needs and abilities of each student. Additionally, AI can assist faculty in analyzing learning data to identify areas that require more attention. While this transition offers many advantages, some faculty and students may experience resistance to change, making it important to provide adequate support and training.

3.6.3 *Management Adaptation:* The context of implementing AI in PTKIN is a crucial step to ensure the successful integration of technology within academic and operational systems. Management needs to develop flexible and responsive strategies to the changes brought about by technology, including in human resource management, infrastructure, and curriculum [49]. Additionally, this adaptation involves forming a team with a deep understanding of AI to lead the implementation and oversight. By involving all stakeholders, including faculty and students, management can create an environment conducive to innovation. his study highlights management adaptability as a critical factor in successful AI integration and educational goal achievement at PTKIN.

3.7 Student Impact

AI can provide opportunities for students to develop new skills relevant to the future job market. Research emphasizes student engagement as a critical factor in AI-enhanced personalized learning environments. Research highlights the digital divide's impact on AI-driven educational disparities.

Student Impact is categorized separately to highlight its distinct focus on the outcomes and challenges specific to students, ensuring their unique needs are addressed independently from institutional Human Resources.

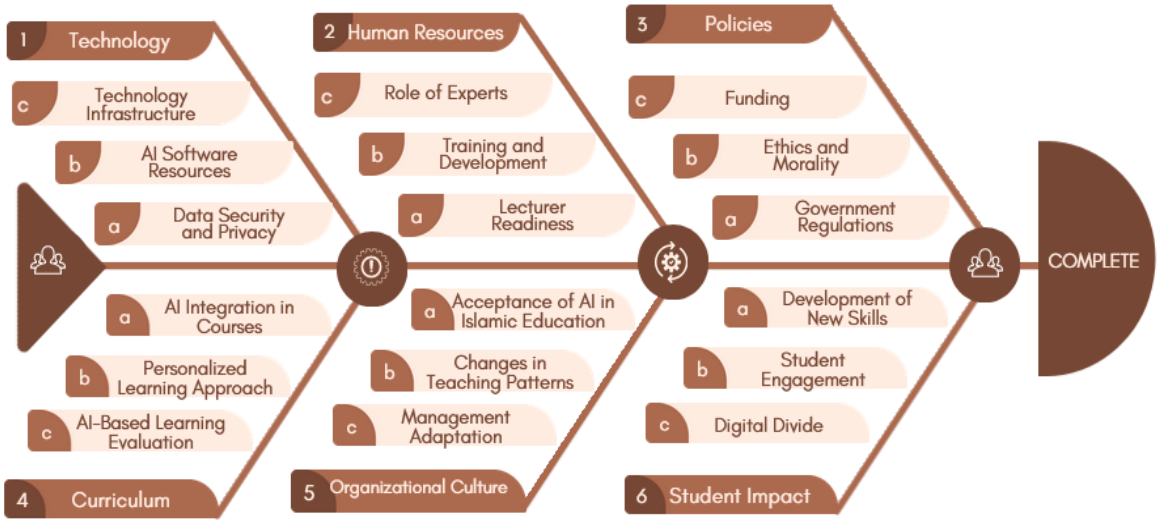

Figure 3. Fishbone diagram analysis

3.7.1 *Development of New Skills:* One of the positive impacts of implementing AI at PTKIN is that students are given opportunities to learn and master skills relevant to the demands of the modern workforce. By using AI, students can explore various tools and technologies that support learning, such as data analysis, programming, and the use of AI-based learning management systems [50]. Research indicates a strong correlation between technological literacy and enhanced employability among graduates. This study examines PTKIN's effective integration of AI-driven projects, fostering graduates' employability and industry readiness. Thus, this development of new skills contributes to improving educational quality and the relevance of graduates in the digital era.

3.7.2 *Student Engagement:* AI-based learning processes at PTKIN are crucial for creating an active and participatory learning experience. AI can enhance student engagement through interactive learning applications, such as e-learning platforms that provide content tailored to individual needs, along with real-time feedback [51]. With this technology, students feel more involved and motivated to learn, as they can see their progress and learning outcomes directly. Research demonstrates AI-enhanced collaborative learning's positive impact on student outcomes. Therefore, by increasing student engagement, PTKIN can foster a more dynamic and innovative learning environment.

3.7.3 *Digital Divide:* This is a significant challenge in implementing AI at PTKIN, where there is a disparity in access and ability between students with adequate technological facilities and those without. Students lacking access to hardware, stable internet connections, or basic technology knowledge may fall behind in a learning process increasingly reliant on AI. The persistence of this gap perpetuates systemic inequalities, undermining academic equity and social mobility. Addressing technological disparities necessitates PTKIN initiatives providing ubiquitous access and pedagogically informed training. By reducing the digital divide, PTKIN can create a more inclusive and equitable educational environment for all students.

3.8 *Negative and Positive Impacts*

3.8.1 *Negative Impacts:* Negative impacts of implementing AI in PTKIN based on the 6M concept (Manpower, Machinery, Methods, Materials, Measurement, and Mother Nature):

Manpower: The increasing use of AI in educational settings prompts consideration of potential workforce implications, including task automation and job displacement. Additionally, not all teaching and administrative staff possess the technical skills to operate AI technology, which can cause anxiety or stress. This also implies a need for intensive and ongoing training to improve workforce readiness and adaptability at PTKIN.

Machinery: Effective AI integration necessitates substantial investments in digital infrastructure and computational resources to ensure scalability and efficiency. The financial burden of AI adoption disproportionately affects resource-constrained PTKIN institutions. Additionally, advanced equipment is often susceptible to technical issues or malfunctions, which can disrupt learning processes and campus operations if there are failures in primary devices or the implemented AI systems.

Methods: AI-based learning methods may raise concerns about human interaction in the educational process. With technology becoming too dominant, there is a risk that interactions between lecturers and students will diminish, reducing the personal touch that may be essential in religious education. The

proliferation of AI in religious education may inadvertently erode the value of interpersonal dialogue and contextualized understanding.

Materials: The content generated or suggested by AI is not always aligned with Islamic values and may not be contextual to the curriculum of PTKIN. This study highlights the necessity of culturally responsive AI integration in Islamic educational contexts. The quality of automated materials can also decline if there is no review by lecturers or experts.

Measurement: The algorithmic nature of AI-based assessments may result in incomplete or inaccurate representations of student competence. Automated evaluations from AI risk overlooking human aspects in the assessment process, such as character values or attitudes that are important in Islamic education. An overreliance on quantitative assessments may compromise the integration of moral and ethical dimensions crucial to PTKIN evaluations.

Mother Nature: Dependence on AI can also impact the learning culture and values at PTKIN. Misaligned AI implementation risks transforming Islamic education into a technocratic model, undermining humanistic and spiritual values. Furthermore, there are environmental impacts stemming from the energy requirements to operate AI systems and the devices used, which can contribute to the institution's carbon footprint.

Overall, the implementation of AI at PTKIN needs to be managed carefully to minimize its negative impacts. PTKIN must ensure that this technology is used wisely (*wise or intelligent ways to achieve goals*), under the principles of Islamic education (*deviation from Moral/Ethical Values*), and supports the holistic development of students without neglecting fundamental religious and humanitarian values.

3.8.2 *Positive Impact:* The positive impact of the implementation of AI in PTKIN based on the 6M concept;

Manpower: AI supports educators, such as lecturers and administrative staff, by providing virtual assistants and automation tools. The strategic deployment of AI in administrative tasks liberates academic staff to concentrate on pedagogical innovation and curriculum enhancement. Virtual assistants can also help students quickly obtain information related to courses or administrative services.

Machinery: With AI, PTKIN can integrate various smart devices, such as voice or visual recognition applications, into learning and research. This technology opens up opportunities for interactive learning and personalized education, where students can engage with learning materials more deeply through AI-based simulations or virtual laboratories, enhancing engagement and understanding.

Methods: AI enables the implementation of more adaptive and data-driven learning methods. AI-based learning systems can analyze each student's learning style and needs, allowing instructors to adopt a more individualized approach. With these more adaptive learning methods, PTKIN can ensure that students learn in ways that align with their abilities and requirements.

Materials: AI facilitates the development and distribution of up-to-date learning materials that align with advancements in knowledge. Instructors can use AI algorithms to curate relevant educational content, such as articles, videos, or interactive modules, that are available online. Additionally, AI can suggest supplementary resources to enrich students' understanding of a subject.

Measurement: In terms of assessment, AI enables a more accurate and efficient evaluation of the performance of students and instructors. The artificial intelligence-enhanced assessment facilitates timely and actionable feedback, promoting autonomous learning and iterative improvement. This also supports a more objective assessment process that aligns with established criteria.

Mother Nature: By leveraging AI, PTKIN can support a greener and more efficient learning environment. Digitalization of learning materials constitutes an environmentally conscious approach, mitigating paper consumption and aligning with sustainable development goals. Additionally, AI helps create an inclusive and diverse learning atmosphere by providing broader access to digital resources, allowing students to learn anytime and anywhere.

This study demonstrates the potential of AI-driven transformation in PTKIN, leveraging the 6M framework to foster efficiency, relevance, and sustainability in Islamic higher education.

3.9 Discussion Results

This study outlines essential steps for successful AI integration in higher education, focusing on PTKIN's context. First, it is important to improve technological infrastructure, such as internet access and devices that support the use of AI. This study emphasizes instructor training as crucial for effective AI integration in education. This study advocates for AI policy development at PTKIN, focusing on data privacy, Islamic values and ethical considerations. The research underscores the necessity of addressing digital disparities in AI-integrated educational settings. This study proposes a sustainable AI integration framework for Islamic educational institutions.

This study emphasizes the importance of contextualized AI implementation strategies at PTKIN. Refer to Table 1 for

a comprehensive comparison of AI's benefits and drawbacks. From the perspective of positive impacts, AI has the potential to enhance the efficiency and effectiveness of the learning process. Research indicates significant reductions in educator workload following AI-driven automation of administrative tasks. The adaptive learning methods offered by AI also help tailor content to the unique needs of each student, thereby improving their learning outcomes. Research highlights AI's role in promoting sustainable education through digitized materials.

However, the negative impacts indicate that AI also brings serious challenges that must be carefully addressed. Dependence on this technology can reduce job opportunities in the education sector, particularly in positions whose tasks can be replaced by automation. This study examines financial constraints impacting AI adoption in resource-limited PTKINs. From a learning methodology perspective, AI also has the potential to diminish personal interaction between educators and students, which is crucial in education based on Islamic values and character guidance. AI's reliance on global data algorithms raises concerns regarding alignment with Islamic values

Table 1. Comparison between Positive Impacts and Negative Impacts

Aspect (6M)	Positive Impacts	Negative Impacts
Manpower	The strategic integration of AI facilitates task automation, liberating educators to concentrate on pedagogically rich activities.	Risking the reduction of certain job opportunities, and creating pressure for faculty and staff to adapt to AI technology.
Machinery	The strategic integration of cutting-edge technology optimizes digital learning, promoting adaptability and academic success.	Requires significant investment in technological infrastructure that may burden the PTKIN budget, and is also prone to technical failures.
Methods	Employs adaptive learning methodologies to address diverse student learning styles and abilities.	This study highlights concerns that AI-driven instruction may attenuate transformative religious learning outcomes.
Materials	Enables the rapid and relevant provision of learning materials, with AI that can adjust content according to needs	This study emphasizes instructor-mediated curation of AI-generated content for Islamic educational contexts.
Measurement	Facilitating the analysis of academic data and student performance quickly and accurately through data-driven algorithms.	Algorithm-based evaluation may overlook human aspects, such as character and ethical values, which are important in Islamic education.
Mother Nature	Encouraging energy efficiency through the digitization of learning and reducing paper usage	Research highlights AI's substantial environmental impact through energy consumption and greenhouse gas emissions.

This study assesses AI's environmental implications in higher education, focusing on PTKIN's digital infrastructure. An Exploratory Study: Technological Progress, Environmental Sustainability, and AI Adoption at PTKIN. High energy consumption needs to be managed with a more environmentally friendly approach, such as investing in renewable energy or implementing more efficient energy management.

A nuanced, multidimensional framework is necessary for optimizing AI's transformative potential within PTKIN. This can be achieved through training for educators, sustainable infrastructure improvements, and the formulation of policies that support the ethical use of AI following Islamic principles. This approach is expected to ensure that AI technology becomes a tool that enhances, rather than replaces, the values of Islamic education at PTKIN.

4 CONCLUSION

This study highlights AI's dual impact on PTKIN. Benefits encompass personalized learning, enhanced accessibility and optimized evaluations. However, challenges persist regarding human capital, data integrity and pedagogical alignment.

These tensions necessitate nuanced governance, ensuring technological innovation aligns with Islamic educational principles. Strategic planning must address human resource development, data security and ethical considerations.

To address these concerns, PTKIN must develop comprehensive policies and strategies, ensuring AI implementation aligns with Islamic principles. Balancing technological advancements with value preservation is crucial.

AUTHOR'S CONTRIBUTION

Aan Ansori served as lead researcher, overseeing concept development, empirical data collection/analysis, fishbone diagram construction, and manuscript drafting/revisions. Syifa Amara Dhestiyani contributed to data collection and preprocessing, writing the introduction, conducting the literature review, and drawing conclusions from the research findings. Meanwhile, Fitri Damyati focused on validating the model used, conducting an in-depth analysis of the fishbone diagram results, structuring the methodology and research findings, and making significant contributions to manuscript editing, ensuring the quality and feasibility of the article.

COMPETING INTERESTS

Following the publication ethics of this journal, Aan Ansori, Fitri Damyati, and Syifa Amara Dhestiyani as the authors of this article declare that this article is free from conflict of interest (COI) and competing interest (CI).

ACKNOWLEDGMENT

The authors express their heartfelt gratitude to the Data and Information Department of the Ministry of Religious

Affairs of the Republic of Indonesia for their valuable contributions, support both morally and materially, as well as constructive corrections and assistance in various ways throughout the research process, which has enabled this study to be completed.

REFERENCES

[1] S. Paek and N. Kim, "Analysis of worldwide research trends on the impact of artificial intelligence in education," *Sustainability*, vol. 13, no. 14, p. 7941, 2021.

[2] H. Lee, "The rise of ChatGPT: Exploring its potential in medical education," *Anat. Sci. Educ.*, vol. 17, no. 5, pp. 926–931, 2024.

[3] B. Lepri, N. Oliver, E. Letouzé, A. Pentland, and P. Vinck, "Fair, transparent, and accountable algorithmic decision-making processes: The premise, the proposed solutions, and the open challenges," *Philos. Technol.*, vol. 31, no. 4, pp. 611–627, 2018.

[4] N. Moustafa, N. Koroniotis, M. Keshk, A. Y. Zomaya, and Z. Tari, "Explainable intrusion detection for cyber defences in the internet of things: Opportunities and solutions," *IEEE Commun. Surv. Tutorials*, vol. 25, no. 3, pp. 1775–1807, 2023.

[5] D. D. Shinde, S. Ahirrao, and R. Prasad, "Fishbone diagram: application to identify the root causes of student–staff problems in technical education," *Wirel. Pers. Commun.*, vol. 100, pp. 653–664, 2018.

[6] P. Clarke and R. V O'connor, "The situational factors that affect the software development process: Towards a comprehensive reference framework," *Inf. Softw. Technol.*, vol. 54, no. 5, pp. 433–447, 2012.

[7] M. Peleg and P. Haug, "Guidelines and workflow models," in *Clinical Decision Support and Beyond*, Elsevier, 2023, pp. 309–348.

[8] E. M. Loredana, "The analysis of causes and effects of a phenomenon by means of the 'fishbone' diagram," *Ann Econ Ser*, vol. 5, pp. 97–103, 2017.

[9] M. Coccia, "Fishbone diagram for technological analysis and foresight," *Int. J. Foresight Innov. Policy*, vol. 14, no. 2–4, pp. 225–247, 2020.

[10] A. Mascia *et al.*, "A failure mode and effect analysis (FMEA)-based approach for risk assessment of scientific processes in non-regulated research laboratories," *Accredit. Qual. Assur.*, vol. 25, pp. 311–321, 2020.

[11] L. A. Clark and D. Watson, "Constructing validity: Basic issues in objective scale development.," 2016.

[12] Z. Xu, Y. Dang, and P. Munro, "Knowledge-driven intelligent quality problem-solving system in the automotive industry," *Adv. Eng. Informatics*, vol. 38, pp. 441–457, 2018.

[13] S. N. Siddiki, J. L. Carboni, C. Koski, and A. Sadiq, "How policy rules shape the structure and performance of collaborative governance arrangements," *Public Adm. Rev.*, vol. 75, no. 4, pp. 536–547, 2015.

[14] F. M. S. Al-Zwainy, I. A. Mohammed, and I. F. Varouqa, "Diagnosing the causes of failure in the construction sector using root cause analysis technique," *J. Eng.*, vol. 2018, no. 1, p. 1804053, 2018.

[15] S. W. J. Kozlowski and B. S. Bell, "Work groups and teams in organizations: Review update," 2013.

[16] A. Shaygan and Ö. M. Testik, "A fuzzy AHP-based methodology for project prioritization and selection," *Soft Comput.*, vol. 23, pp. 1309–1319, 2019.

[17] F. Lamnabhi-Lagarrigue *et al.*, "Systems & control for the future of humanity, research agenda: Current and future roles, impact and grand challenges," *Annu. Rev. Control*, vol. 43, pp. 1–64, 2017.

[18] F. Pakdil and F. Pakdil, "Analyze Phase: Other Data Analysis Tools," *Six Sigma Students A Probl. Methodol.*, pp. 291–331, 2020.

[19] M. J. Ershadi, R. Aiasi, and S. Kazemi, "Root cause analysis in quality problem solving of research information systems: a case study," *Int. J. Product. Qual. Manag.*, vol. 24, no. 2, pp. 284–299, 2018.

[20] A. Banawi and M. M. Bilec, "A framework to improve construction processes: Integrating Lean, Green and Six Sigma," *Int. J. Constr. Manag.*, vol. 14, no. 1, pp. 45–55, 2014.

[21] M. M. Mandelburger and J. Mendling, "Cognitive diagram understanding and task performance in systems analysis and design," *MIS Q.*, vol. 45, no. 4, pp. 2101–2157, 2021.

[22] S. A. Khan, M. A. Kaviani, B. J. Galli, and P. Ishtiaq, "Application of continuous improvement techniques to improve organization performance: A case study," *Int. J. Lean Six Sigma*, vol. 10, no. 2, pp. 542–565, 2019.

[23] D. Korać and D. Simić, "Fishbone model and universal authentication framework for evaluation of multifactor authentication in mobile environment," *Comput. Secur.*, vol. 85, pp. 313–332, 2019.

[24] L. Liliana, "A new model of Ishikawa diagram for quality assessment," in *Iop conference series: Materials science and engineering*, 2016, vol. 161, no. 1, p. 12099.

[25] K. Berladir, T. Hovorun, J. Trojanowska, V. Ivanov, and A. Iakovets, "Failure Analytics of Defects in Mechanical Engineering Parts Using Root Cause Analysis: Case Study," in *International Scientific-Technical Conference MANUFACTURING*, 2024, pp. 328–341.

[26] B. Mahapatro, *Human resource management*. New Age International (P) ltd., 2021.

[27] Z. Shan, S. Qin, Q. Liu, and F. Liu, "Key manufacturing technology & equipment for energy saving and emissions reduction in mechanical equipment industry," *Int. J. Precis. Eng. Manuf.*, vol. 13, pp. 1095–1100, 2012.

[28] W. Van Der Aalst and K. M. Van Hee, *Workflow management: models, methods, and systems*. MIT press, 2004.

[29] K. I. Praseeda, B. V. V. Reddy, and M. Mani, "Embodied energy assessment of building materials in India using process and input–output analysis," *Energy Build.*, vol. 86, pp. 677–686, 2015.

[30] K. Keong Choong, "Understanding the features of performance measurement system: a literature review," *Meas. Bus. Excell.*, vol. 17, no. 4, pp. 102–121, 2013.

[31] J. A. Ramírez, R. L. Boroschek, R. Aguilar, and C. E. Ventura, "Daily and seasonal effects of environmental temperature and humidity on the modal properties of structures," *Bull. Earthq. Eng.*, ol. 20, no. 9, pp. 4533–4559, 2022.

[32] R. Chambers, *Ideas for development*. Routledge, 2013.

[33] R. E. Wood, "Task complexity: Definition of the construct," *Organ. Behav. Hum. Decis. Process.*, vol. 37, no. 1, pp. 60–82, 1986.

[34] A. Booth, M.-S. James, M. Clowes, and A. Sutton, "Systematic approaches to a successful literature review," 2021.

[35] R. Sagor, *The action research guidebook: A four-stage process for educators and school teams*. Corwin Press, 2011.

[36] T. H. Poister, M. P. Aristigueta, and J. L. Hall, *Managing and measuring performance in public and nonprofit organizations: An integrated approach*. John Wiley & Sons, 2014.

[37] W. J. Kettinger, J. T. C. Teng, and S. Guha, "Business process change: a study of methodologies, techniques, and tools," *MIS Q.*, pp. 55–80, 1997.

[38] O. Enaizan *et al.*, "Electronic medical record systems: Decision support examination framework for individual, security and privacy concerns using multi-perspective analysis," *Health Technol. (Berl).*, vol. 10, pp. 795–822, 2020.

[39] J. N. Davies, M. Verovko, O. Verovko, and I. Solomakha, "Personalization of e-learning process using ai-powered chatbot integration," in *International scientific-practical conference*, 2020, pp. 209–216.

[40] D. Sargiotis, "Data Security and Privacy: Protecting Sensitive Information," in *Data Governance: A Guide*, Springer, 2024, pp. 217–245.

[41] A. Ali, "Assessing Artificial Intelligence Readiness of Faculty in Higher Education: Comparative Case Study of Egypt." The American University in Cairo (Egypt), 2023.

[42] I. Gligorea, M. Cioca, R. Oancea, A.-T. Gorski, H. Gorski, and P. Tudorache, "Adaptive learning using artificial intelligence in e-learning: a literature review," *Educ. Sci.*, vol. 13, no. 12, p. 1216, 2023.

[43] A. Ezzaim, A. Dahbi, A. Aqqal, and A. Haidine, "AI-based learning style detection in adaptive learning systems: a systematic literature review," *J. Comput. Educ.*, pp. 1–39, 2024.

[44] S. Hernawati, M. Hafizh, and M. N. A. Rahardja, "Adjusting the ideal Islamic religious education curriculum to the development of AI-based technology," *Progres. J. Pemikir. dan Pendidik. Islam*, vol. 13, no. 01, pp. 129–144, 2024.

[45] A. Nguyen, H. N. Ngo, Y. Hong, B. Dang, and B.-P. T. Nguyen, "Ethical principles for artificial intelligence in education," *Educ. Inf. Technol.*, vol. 28, no. 4, pp. 4221–4241, 2023.

[46] N. Miailhe, C. Hodes, A. Jain, N. Iliadis, S. Alanoca, and J. Png, "AI for sustainable development goals," *Delphi*, vol. 2, p. 207, 2019.

[47] B. P. Woolf, *Building intelligent interactive tutors: Student-centered strategies for revolutionizing e-learning*. Morgan Kaufmann, 2010.

[48] L. Chen, P. Chen, and Z. Lin, "Artificial intelligence in education: A review," *Ieee Access*, vol. 8, pp. 75264–75278, 2020.

[49] C. Bailey, D. Mankin, C. Kelliher, and T. Garavan, *Strategic human resource management*. Oxford university press, 2018.

[50] R. Luckin and M. Cukurova, "Designing educational technologies in the age of AI: A learning sciences-driven approach," *Br. J. Educ. Technol.*, vol. 50, no. 6, pp. 2824–2838, 2019.

[51] Y.-A. Bachiri, H. Mouncif, and B. Bouikhalene, "Artificial intelligence empowers gamification: Optimizing student engagement and learning outcomes in e-learning and moocs.," *Int. J. Eng. Pedagog.*, vol. 13, no. 8, 2023.