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A Transformative PAR (Participatory Action Research) Paradigm in AI Engineering: Towards Adaptive and Humanistic Vocational Learning

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Abstract

Artificial Intelligence (AI) presents significant prospects for personalizing learning experiences. However, technology-oriented engineering paradigms cannot often adapt comprehensively and support fundamental human aspects, thus risking the creation of systems perceived as rigid. This paper aims to articulate a transformative paradigm for AI engineering within the context of vocational education by integrating Participatory Action Research (PAR) principles. Using a systematic literature synthesis approach, this paper examines the challenges in human-centered AI engineering and analyzes the potential of PAR as a methodological framework. The result is an integrated conceptual model that aligns the PAR cycle with the AI system development lifecycle, positioning learners and educators as co-design partners. The PAR paradigm offers substantial potential to direct the evolution of AI engineering toward learning systems that are technically adaptive, contextually relevant, and substantively humanistic.

Keywords: *Adaptive learning; Artificial intelligence; Humanistic education; Participatory action research; Vocational education*

1. Introduction

Global civilization is amid the Fourth Industrial Revolution, an era marked by the convergence of physical, digital, and biological technologies that fundamentally alter the employment landscape. This transformation places significant pressure on the vocational education sector, which is now required not only to equip graduates with procedural and technical skills (hard skills) but also with adaptive capabilities, complex problem-solving abilities, and socio-emotional intelligence. Amidst these challenges, Artificial Intelligence (AI) has emerged as a technology with a highly promising value proposition. AI offers the potential to revolutionize pedagogy through personalized learning systems capable of dynamically adjusting materials, pace, and learning paths according to the unique profile of each learner.

However, behind these brilliant prospects lies a crucial paradox. Today's dominant AI engineering paradigm focuses on technical optimization and algorithmic efficiency. This techno-centric approach, if not balanced with mature pedagogical and humanistic considerations, risks causing the dehumanization of the learning process. Learning can be reduced to transactional interactions between humans and machines, neglecting fundamental aspects such as social interaction, intrinsic motivation, and emotional well-being. The gap between AI's technological potential and the need for a humanistic learning approach signifies a methodological void. Existing development models are often top-down, where technical experts design technology and then "deliver" to educators and learners, resulting in solutions that are not fully aligned with the complex realities of the learning context.

This paper aims to articulate and propose a transformative conceptual framework in response to this methodological void. This framework integrates Participatory Action Research (PAR) principles—an approach that emphasizes collaboration, reflection, and empowerment—into the practice of AI engineering. The originality of this idea lies in positioning PAR not merely as an evaluation method but as a core paradigm inherent in the entire design and development process of AI itself. Thus, this research seeks to answer how PAR principles can be systematically integrated into the AI engineering lifecycle to guide the development of vocational learning systems that are both adaptive and humanistic.

To answer these questions systematically, this paper is organized into several sections. Following this introduction, Section 2 will present a comprehensive literature review covering three main pillars: the landscape of AI engineering in education, the foundations of adaptive and humanistic learning, and the essence of PAR as a transformative methodology. Section 3 will be the core of this paper, where we articulate the proposed integrated PAR-AI paradigm in depth. Finally, Section 4 will conclude the paper by presenting a summary, a reflection on the research limitations, and recommendations for future research directions.

2. Comprehensive Literature Review

This section presents the theoretical foundation that supports the main argument of this paper. The literature review is organized into three main pillars. First, we will map the landscape of Artificial Intelligence (AI) engineering in educational technology, identifying its evolution, technical architecture, and inherent ethical challenges. Second, we will discuss the conceptual foundations of adaptive and humanistic learning as ideal pedagogical goals. Third, we will elaborate on Participatory Action Research (PAR) as a transformative methodology that has the potential to bridge the gap between technology engineering and humanistic educational goals.

2.1. The Landscape of AI Engineering in Educational Technology

2.1.1. Historical Evolution: From ITS to Modern AI Ecosystem

The effort to integrate artificial intelligence into education is not a new idea. The literature indicates that its roots can be traced back to the 1970s and 1980s with the development of rule-based Intelligent Tutoring Systems (ITS) [1]. The data explosion shifted the focus toward machine learning-based approaches for applications like Learning Analytics to predict student performance [2]. We are currently in a third wave dominated by deep learning, which enables more advanced capabilities such as natural language processing for automated essay grading and computer vision to analyze practical skills performance in simulation environments [3].

2.1.2. Technical Architecture of Adaptive Learning Systems

In general, the technical architecture of an adaptive learning system can be decomposed into four core interacting components [4]. The first is the Domain Model. The second is the Learner Model, which dynamically tracks the learner's state. Methods like Bayesian Knowledge Tracing (BKT) are often used to probabilistically model knowledge acquisition [5]. The third is the Pedagogical Model, which makes instructional decisions. The fourth is the User Interface. Recent research in educational systems engineering often focuses on optimizing the allocation of computational resources in cloud-based architectures to efficiently serve thousands of users [6].

2.1.3. Critical Issues: Ethical and Privacy Challenges in Educational AI

Behind the technical advancements, the application of AI raises a series of ethical challenges. One of the main issues is algorithmic bias, where systems risk perpetuating existing social inequalities [7]. The second issue relates to data privacy and security. To address this, some engineering research focuses on developing lightweight cryptographic protocols to secure the exchange of student data [8]. Lastly, the "black box" problem in complex AI models poses challenges in terms of transparency and accountability, requiring clear AI governance frameworks [9]

2.2. Foundations of Adaptive and Humanistic Learning

To address the challenges previously outlined, it is crucial to understand in depth the ultimate goal of the learning systems themselves, namely, learning that is both adaptive and humanistic. Rather than being mutually exclusive, these two concepts form a synergistic foundation for effective modern education.

2.2.1. Key Dimensions of Adaptive Learning

Adaptivity in learning extends far beyond mere adjustments in difficulty levels. The literature identifies several key dimensions through which a system can adapt to a learner [10]. Content Adaptation involves presenting information through various modalities (e.g., text, video, interactive simulations) based on the learner's inferred preferences or diagnosed learning style, thereby accommodating diverse cognitive needs [11]. Learning Pace Adaptation allows each learner to progress through the material at their speed, providing extra support for those who struggle and offering advanced pathways for those who excel, thus avoiding the "one-size-fits-all" limitation of traditional classrooms.

Furthermore, Assessment Adaptation, most notably implemented in Computerized Adaptive Testing (CAT), tailors the difficulty of subsequent questions based on the learner's previous answers, leading to a more efficient and precise measurement of their ability level [12]. The most sophisticated dimension is Learning Path Adaptation, where the system dynamically curates a unique sequence of topics and learning activities for each individual. This creates a truly personalized curriculum based on the learner's long-term goals, prior knowledge, and real-time performance, guiding them through the knowledge space in the most optimal way [10].

2.2.2. Philosophical Review of Humanistic Education

Humanistic education provides the essential philosophical foundation to ensure that technology serves, rather than subverts, human development. The theories of humanistic psychologists offer timeless principles for this endeavor. The work of Abraham Maslow, with his concept of a hierarchy of needs, reminds us that learners must feel safe, secure, and have a sense of belonging before they can engage in higher-order thinking and achieve self-actualization [13]. Similarly, Carl Rogers' idea of person-centered education emphasizes the educator's role as a facilitator who creates a climate of unconditional positive regard and empathic understanding to foster authentic growth from within the learner [14].

Moreover, the philosophy of John Dewey, which champions experiential learning or "learning by doing," is highly relevant. Dewey argued that learning is most effective when it is active, situated in authentic problems, and involves social interaction [15]. A humanistic approach, therefore, values not just acquiring knowledge but the development of the whole person through experience, reflection, and collaboration.

2.2.3. Adaptive-Humanistic Synthesis for the Vocational Context

The context of vocational education is an ideal arena for the synthesis of adaptive efficiency and humanistic depth. The modern workplace demands professionals who are both technically proficient and humanly adept—resilient, creative, and collaborative. An AI system that is only adaptive in a technical sense is insufficient. A proper synthesis is required.

One practical manifestation of this synthesis is the application of gamification, where elements of game design are integrated into the learning context to increase motivation. This approach uses adaptive technology (e.g., adjusting challenges based on skill level) to tap into fundamental human drives for achievement, competition, and social connection—a humanistic goal [16]. Previous research by the author has demonstrated the successful development of gamification-based learning applications on the Android platform to enhance student's learning interest in informatics, serving as a concrete example of a user-experience-oriented engineering effort [17].

Another example of this synthesis is the concept of AI-supported Collaborative Learning. In this model, an AI does not merely interact with an individual but acts as a facilitator for group work. It could help form teams based on complementary skills, monitor team dynamics for potential conflicts, and provide resources to support a collaborative project [18]. Such a system would be technically adaptive while directly serving the humanistic goal of developing crucial social and teamwork skills, thereby cultivating a holistic professional ready for the demands of the modern industry.

2.3. Participatory Action Research as a Transformative Methodology

2.3.1. Historical Roots and Fundamental Principles of PAR

Participatory Action Research (PAR) is not a single method but an orientation to inquiry that seeks to create knowledge grounded in the experiences and needs of communities [19]. Its historical roots can be traced to the post-World War II work of social psychologist Kurt Lewin, who coined the term "action research" to describe solving practical problems through a cyclical process of planning, acting, and fact-finding about the results of the action. Lewin's famous adage, "no research without action, and no action without research," underscores the inseparability of inquiry and practice [20]. However, the "participatory" and "critical" dimensions of PAR were significantly enriched by the work of educators and social theorists like Paulo Freire. Working with oppressed communities in Brazil, Freire argued for a dialogical approach to education and research, aiming for "conscientização," or critical consciousness, where people become subjects who analyze and transform their reality rather than objects of study [21]. From this synthesis, several fundamental principles of PAR emerge: a dual commitment to producing knowledge and fostering social change, a collaborative relationship that honors local knowledge, and the primacy of iterative cycles of action and reflection [19].

2.3.2. Deconstruction of the PAR Cycle: Plan, Act, Observe, and Reflect

The PAR cycle is the engine that drives this methodology forward in a spiral of continuous learning and improvement. While presented as distinct phases, they are fluid and often overlap in practice [19]. The Planning phase begins with collectively identifying and diagnosing a practical problem. It involves stakeholder analysis and collaborative mapping to ensure the research question is relevant and owned by the community. The Acting phase consists of implementing the planned intervention or change in a deliberate and controlled manner. This action is treated as a "test" in a real-world context. The Observing phase is a systematic process of gathering data about the effects and process of the action. This is inherently a mixed-methods phase, often combining qualitative data (e.g., field notes, participant journals, interviews) with quantitative data (e.g., surveys, performance metrics) to capture a rich picture of what is happening [22]. Finally, the Reflecting phase is a critical moment where all participants come together to make sense of the data, challenge their own assumptions, celebrate successes, learn from failures, and, most importantly, use these new insights to re-plan the next, more informed cycle of action.

2.3.3. PAR in the Design Realm: Bridging Social Science and Human-Computer Interaction (HCI)

The potential of PAR resonates strongly with and extends beyond social science research into the realm of technology design. The field of Human-Computer Interaction (HCI) has long recognized the limitations of expert-driven design. This led to the rise of the Participatory Design (PD) movement, particularly in Scandinavia, which advocated for the active involvement of end-users (e.g., factory workers and nurses) in the design of the technologies they would use in their daily work [23]. PD shares PAR's commitment to democratizing the design process and valuing experiential knowledge. It differs from the more common User-Centered Design (UCD) approach, where users are often consulted as data sources or feedback by positioning them as equal partners and co-designers in the creative process [24]. Studies in the HCI and Computer-Supported Cooperative Work (CSCW) literature have repeatedly shown that participatory approaches lead to technologies that are more usable, more readily adopted, and better aligned with users' complex, situated practices [25]. PAR, therefore, offers a robust methodological and ethical framework to ground these design practices in a commitment to social transformation and empowerment.

3. Articulation of the Integrated Paradigm: PAR in AI Engineering

Having established the theoretical foundation in the previous chapter, this section will articulate the proposed new paradigm integrating Participatory Action Research (PAR) into the Artificial Intelligence (AI) engineering process. This paradigm does not view PAR as an additional activity but as a fundamental framework that guides the entire system development lifecycle. Its goal is to ensure that the resulting technological product is inherently adaptive, humanistic, and relevant to vocational education.

3.1. Guiding Principles for PAR-AI Integration

A set of fundamental principles must guide a meaningful integration between PAR and AI engineering. These principles serve as the philosophical and ethical foundation for the proposed process model.

3.1.1. Epistemic Partnership Principle

This principle asserts that all forms of knowledge hold equal value. The experiential knowledge of learners and educators is as necessary as the technical knowledge of AI engineers. In this paradigm, the traditional hierarchy where the engineer is considered the sole expert is dismantled and replaced by a partnership ecosystem where all parties are essential knowledge contributors.

3.1.2. Reflective Iteration Principle

System development is not viewed as a linear process from analysis to implementation. Instead, the process is cyclical and spiral, which aligns with PAR's nature. Each development cycle must conclude with a pause for structured, collective reflection. In these reflection sessions, all stakeholders jointly analyze successes, failures, and lessons learned to inform the direction of the next development cycle.

3.1.3. Technological Empowerment Principle

The ultimate goal of AI development in this paradigm is not merely to create "efficient" or "intelligent" products. The goal is empowerment. The resulting technology must enhance all stakeholders' agency, autonomy, and capabilities—empowering learners to take control of their learning process and empowering educators with tools that support, rather than replace, their pedagogical wisdom.

3.2. The Integrated PAR-Agile Process Model

To translate the above principles into concrete engineering practice, we propose the Integrated PAR-Agile Process Model. This model aligns the PAR cycle with the agile software development methodology, particularly the Scrum framework, which is also iterative.

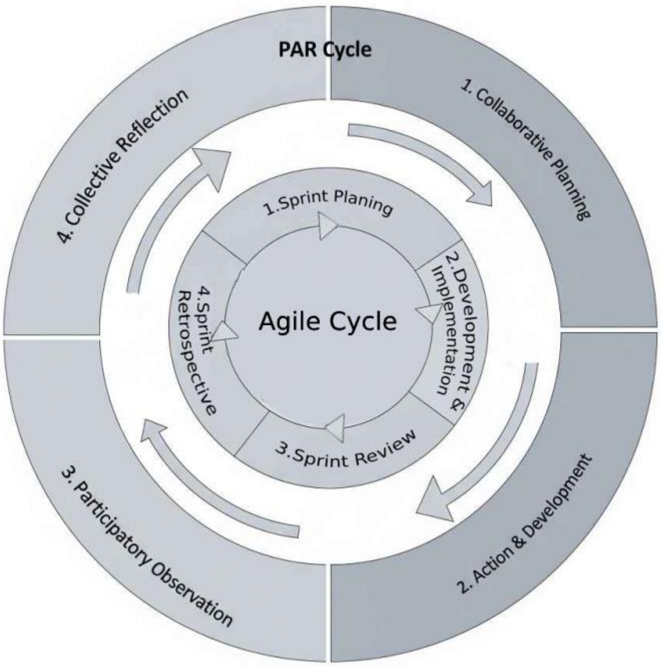

Fig 1: The Integrated PAR-Agile Process Model

The following is an explanation of each phase in the integrated model:
Phase 1: Collaborative Planning (PAR) & Sprint Planning (Agile) In this phase, a core team of engineers, educators, and learner representatives convenes. This session is more than just a technical sprint planning meeting. Using facilitation techniques from PAR, the team collaboratively defines the pedagogical problem to be solved in the sprint. They formulate an "action hypothesis": "If we build feature X, we expect it will increase learning motivation (measured by metric Y)." The output of this phase is a sprint backlog containing a list of technical tasks, where each item has a clear pedagogical and humanistic justification.
Phase 2: Action & Development (PAR) & Development (Agile) The engineering team begins to build and implement the agreed-upon features. However, this process does not occur in isolation. Educators and learners are periodically involved in providing formative feedback on early prototypes, ensuring the user interface design and interaction flow are appropriate for the real-world classroom context.
Phase 3: Participatory Observation (PAR) & Sprint Review (Agile) At the end of the sprint, a sprint review session is held. This session is more than just a software demonstration; it is a participatory observation session. Learners and educators actively use the new feature in a simulated or real learning scenario. Data is collected not only in the form of technical notes (bugs) but also qualitative data regarding user experience, emotional responses, and emerging learning dynamics.
Phase 4: Collective Reflection (PAR) & Sprint Retrospective (Agile) This phase is the heart of the PAR-Agile paradigm. The sprint retrospective session is expanded to include the entire core team. Using data from the observation phase, the team collectively reflects on

deep questions: "Was our action hypothesis proven? Does this feature truly empower learners? What unexpected impacts emerged? What have we learned about our own learning and development processes?" The insights from this collective reflection become the foundation for planning the next PAR-Agile cycle.

3.3. Transformation of Stakeholder Roles

Implementing this model demands a fundamental transformation in the roles and relationships among stakeholders.
Learners: Shift from being passive objects or "end-users" to becoming co-design partners. They are the experts of their own learning experiences, and their voices become a primary data source for innovation.
Educators: Change from being mere "recipients" of technology to becoming practitioner-researchers and pedagogical facilitators. They use the tools and actively shape them and research their impact on their teaching practices.
AI Engineers: Evolve from being isolated "builders" of solutions to becoming technical partners and contextual learners. They are required to develop empathy and a deep understanding of the educational world and to be able to translate complex pedagogical needs into elegant technical solutions.

3.4. Methodological and Practical Implications

The application of the PAR-AI paradigm carries several important implications. Methodologically, this approach is inherently mixed-methods. It requires strategies to collect and analyze quantitative data from system logs (e.g., completion time, success rates) alongside rich qualitative data from interviews, observations, and focus group discussions.

Practically, this approach is not without its challenges. The demand for time and resources is clearly greater than in conventional development models. Building trust and facilitating effective communication among groups with very different backgrounds requires high-level facilitation skills. Furthermore, the issue of scalability becomes an important question: how can this intensive participatory process be applied in the development of large-scale systems? Mitigation strategies may include implementation in pilot projects first and the use of carefully selected stakeholder representatives.

3.5. Comparison of AI Development Paradigms for Education

To translate the idea of integrating PAR and AI engineering into an operational model, a series of guiding principles are required to serve as the philosophical and ethical foundation, as presented in Table 1 below.

Table 1: Comparison of AI Development Paradigms for Education

Aspect of Comparison	Traditional AI Engineering	PAR-AI Paradigm (Proposed)
User Role	Users (learners & educators) as test subjects or passive data sources.	Users are co-design partners and experts in their own experience.
Primary Goal	To create efficient, technically accurate systems that can automate tasks.	To empower learners and educators and to enhance the quality of the entire learning experience.
Development Process	It tends to be linear and top-down (from technical experts to users).	Iterative and collaborative cycles (bottom-up & top-down).
Source of Innovation	Stems from advancements in technology and algorithms.	Stems from real-world practical problems identified jointly within the learning context.
Success Metrics	Predictive accuracy, computational speed, and reduction of technical errors.	Positive pedagogical impact, increased user agency, well-being, and learning motivation.
Nature of Feedback	Feedback is typically collected at the end for validation (summative feedback).	Feedback is collected continuously in each cycle for improvement (formative feedback).

3.6. Transformasi Peran Pemangku Kepentingan

The implementation of the PAR-AI paradigm inherently shifts the traditional roles of stakeholders. The matrix in Table 2 articulates this new distribution of roles and responsibilities, highlighting the collaborative nature and equitable roles among learners, educators, and AI engineers throughout the development cycle.

Table 2: Matrix of Roles and Responsibilities in the PAR-AI Paradigm

Cycle Phase	Learner's Role (Co-designer)	Educator's Role (Facilitator & Researcher)	AI Engineer's Role (Technical Partner)
1. Planning	Articulating learning challenges from personal experience. Contributing to defining goals and "user stories."	Establishing pedagogical goals for the cycle. Facilitating discussions and translating curriculum needs into features.	Listening to user needs. Translating pedagogical goals into technical specifications and managing the sprint backlog.
2. Development	Providing formative feedback on early prototypes. Participating in usability testing sessions.	Validating that developed features align with learning objectives and the designed pedagogical flow.	Developing the software according to the sprint backlog. Iteratively implementing feedback from users.
3. Observation	Using new features in authentic learning scenarios. Serving as the primary subject for experience data collection.	Observing the learning process and interactions. Collecting qualitative data (field notes, brief interviews).	Collecting quantitative data from the system (interaction logs, performance metrics). Identifying technical and usability issues.
4. Reflection	Interpreting data from a personal perspective. Voicing what worked/failed and proposing ideas for the next cycle.	Analyzing data (qualitative & quantitative) to evaluate pedagogical impact. Leading the reflective discussion.	Presenting technical findings. Providing input on the technical feasibility of new ideas that emerge for the next cycle.

4. Conclusion

This conceptual research arose from the identification of a fundamental gap between the rapid advancement of Artificial Intelligence (AI) engineering and the need for a humanistic, learner-centered approach, particularly within the context of vocational education. The dominant AI engineering paradigm, which tends to be oriented towards technical optimization, often fails to accommodate the complexity of the human experience in learning. To address this challenge, this paper has articulated an integrated alternative paradigm by incorporating the principles and cycles of Participatory Action Research (PAR) into the agile development methodology.

The main contribution of this research is the proposal of the Integrated PAR-Agile Process Model, a framework that positions learners and educators not as passive users but as equal co-design partners with AI engineers. By aligning the PAR cycle (Collaborative Planning, Action & Development, Participatory Observation, and Collective Reflection) with the agile cycle (Sprint Planning, Development, Review, and Retrospective), this model offers a systematic workflow to ensure that the developed AI technology is inherently pedagogically relevant, empowering, and humanistic. The transformation of stakeholder roles is a central pillar of this paradigm, where collaboration and reflection become the engines of innovation.

Of course, this research has its limitations. As a conceptual study, the proposed model still requires empirical validation to test its effectiveness and challenges in real-world educational contexts. Therefore, future research directions are wide open. The most logical next step is to apply this PAR-Agile framework in a longitudinal case study, for instance, in developing an AI-based programming learning system that integrates gamification and Social Emotional Learning to directly measure its impact on student engagement, motivation, and learning outcomes. Such research would validate this model and generate valuable insights for the engineering and educator communities in their joint effort to create a better future for educational technology.

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