

Adaptive AI-Based Training Models For Public Servants In Small And Medium Brazilian Municipalities: Opportunities And Challenges

Author

Abstract:

Training public servants in small Brazilian municipalities runs into well-documented limits: tight budgets, few local specialists, and a persistent gap between what training programs teach and what civil servants actually do. On top of that, practical know-how tends to sit with experienced employees who have no structured way to pass it on. Adaptive training platforms based on Artificial Intelligence (AI), built on reinforcement learning, intelligent tutoring, and machine learning, can adjust each learner's path without depending on in-person instructors. This article asks whether and how those capabilities fit the specific context of Brazilian municipalities. It cross-references a review of international literature with empirical data collected in Fraiburgo and Florianópolis (Santa Catarina, Brazil) through semi-structured interviews and a 5-point Likert scale. What adaptive platforms offer lines up with what the municipalities actually need: closing the gap between theory and practice, providing post-training support, and externalizing tacit knowledge. Real barriers also showed up — insufficient digital infrastructure, the cold-start problem, institutional resistance, and compliance with the Brazilian General Data Protection Law (LGPD). The article proposes a gradual adoption strategy, including shared content development across municipalities through intermunicipal consortia.

Key Word: Artificial Intelligence; Adaptive Training; Municipal Public Servants; Reinforcement Learning; Local Government; Workforce Capacity Building.

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I. Introduction

Brazilian municipalities face significant challenges in training their public workforce, particularly in settings marked by limited fiscal capacity, insufficient technological infrastructure, and weak institutional capacity, as is the case in most small cities. These challenges are aggravated by the increasing complexity of public management activities, the rollout of new technologies tied to digital government initiatives, and an evolving legislative system that includes compliance with frameworks such as the General Data Protection Law (LGPD). To put the scale of the problem in perspective, Brazil has approximately 5,570 municipalities, and a substantial share of them are small or medium-sized cities that struggle with specific obstacles in training their public servants [1].

As work in the sector grows more complex, the technology market itself is moving at a pace that is hard to keep up with. Recent developments in artificial intelligence (AI), in particular, have opened up new possibilities for personalized and adaptive training systems that can fit the experience to each learner's needs, preferences, and performance level. Within the educational field, Kuleto et al. [2] show how those AI advances created new room for personalized and adaptive training. AI-based adaptive training platforms have emerged as a promising alternative to traditional approaches, offering benefits such as personalized learning, scalability, and resource efficiency. These models could change the way public servants are trained, but their effectiveness depends on adequate technological infrastructure and on the continuous training of the educators involved [3].

Despite the growing volume of research on AI-based adaptive training and the well-documented training needs in Brazilian municipalities, very little work has examined how this kind of platform applies, holds up, and what it would take to deploy it specifically for public servants in small Brazilian municipalities. The gap matters because these municipalities work under resource and capacity constraints that affect both whether AI-based training is needed and whether it is feasible. This study addresses that gap by exploring how the implementation of AI-based adaptive training models can be carried out effectively in such localities.

The article tackles four research questions. First, what are the main characteristics and functions of AI-driven adaptive training systems described in recent studies? Second, what are the training requirements, organizational obstacles, and configurations of public employees in small Brazilian municipalities? Third, how do the functions of AI-driven adaptive training systems meet the requirements and training environments of municipal public employees in Brazil? And finally, what are the main opportunities, challenges, and factors to consider when deploying AI-driven adaptive training in small Brazilian municipalities?

By placing international research on AI-based adaptive training platforms alongside empirical evidence from training programs for public servants in Brazilian municipalities, this article aims to deliver a grounded analysis of the opportunities and challenges of applying AI technologies to the specific context of training public servants in small Brazilian municipalities.

II. Theoretical Framework

AI-Based Adaptive Training Platforms

AI-based adaptive training platforms, also called adaptive training systems, mark a substantial shift away from traditional learning and training approaches. By relying on machine learning algorithms and learner modeling to customize learning experiences in real time, these systems combine multiple AI methodologies, including reinforcement learning, natural language processing, and predictive analysis. The result is a class of educational technological artifacts that can build personalized learning trajectories adjusted to each student's needs, preferences, and performance level [4].

The theory behind AI-driven adaptive training rests on the principles of personalized learning, which hold that learning becomes more effective when instructional content, pace, and pedagogical methodologies are aligned to each student's particular profile [5]. Current adaptive learning systems implement that personalization through continuous cycles of evaluation, analysis, and content rewriting, in which the student's performance feeds the inputs that drive agile changes in instructional strategies [6].

The key components of AI-based adaptive training platforms include:

1. **Learner Models:** computational representations of the learner's knowledge, skills, learning preferences, and cognitive states, continuously updated based on the learner's interactions [3].
2. **Domain Models:** structured representations of the learning content, including relationships between concepts, prerequisites, and competency structures [7]. These domain models matter because they ensure content is presented in a logical sequence, which helps the learning process for public servants.
3. **Adaptive Engines:** algorithms that process data from the learner model and the domain model to make decisions about content selection, especially for instructional sequencing and presentation [8]. These engines are central to the success of adaptive training systems because they make personalization possible in a way that fits how public servants actually learn.
4. **Learning Interfaces:** user environments that present personalized content and gather data from every learner interaction to update the model [3].

Empirical research on AI-based adaptive training platforms has produced encouraging findings on several fronts, ranging from improvements in learning outcomes to higher student engagement and training efficiency across educational and corporate contexts. Meta-analyses indicate that adaptive learning systems can produce learning gains comparable to one-on-one human tutoring, particularly when implemented with well-built domain modeling and instructional design [9].

Training of Municipal Public Servants in Brazil

Training public servants in Brazilian municipalities operates inside a specific institutional and regulatory environment, with characteristics that set it apart from federal and state services. The basic legal framework includes the 1988 Federal Constitution, which sets out principles for public administration, and several federal laws that establish guidelines for training and qualification. The autonomy granted to municipalities by the Constitution generates significant variation in how training policies are implemented in practice, and that variation is sharper in smaller municipalities, where administrative and fiscal capacity are more limited [1].

Even though the legal framework requires continuous training of public servants, how that requirement is put into practice varies substantially across municipalities [10]. Many do not have formalized training policies, systematic processes for assessing internal needs, or even mechanisms for evaluating whether the training they offer is working.

As for what these municipal public servants actually need to learn, the demands cover financial management, legislation, digital technologies, and direct service to citizens. The growing complexity of public administration, especially in connection with newer regulatory structures such as the LGPD and digital government initiatives, has added training demands that overload municipalities.

Existing training programs in Brazilian municipalities mostly use traditional in-person training, often delivered through government schools or partner institutions [11]. The format does have its merits, including direct interaction between instructors and participants, but it also runs into limits around scalability, accessibility, and the ability to address individualized learning needs.

The literature on training municipal public servants in Brazil points to a clear need for more effective, scalable, and personalized training approaches, ones capable of dealing with both the resource constraints and the diverse training needs of staff in small municipalities. AI-based adaptive training platforms come up as a

promising alternative, but using them well calls for careful attention to the contextual factors that define the Brazilian municipal environment.

Institutional Constraints and Resources of Small Municipalities

The institutional capacity of Brazilian municipalities is decisive for whether any training initiative is viable. Fernandes et al. [1] document that small municipalities, which make up the largest share of the country's federative units, face fiscal constraints that systematically limit investment in personnel development. In practice, those constraints translate into reduced training budgets, lack of specialized teams in personnel management, insufficient technological infrastructure, and difficulty hiring qualified instructors.

Carving out time for training is another obstacle that came up repeatedly in the research. Servants with multiple assignments and overloaded operational agendas reported difficulty in reconciling participation in training sessions with the day-to-day demands of the job. The finding is consistent with Amaral's argument [12] that, when municipalities lack formalized training policies, they end up running occasional, disconnected actions that have no real grip on what servants actually need and that fail to produce sustained competency development.

Current Programs and Approaches to Training

Training in Brazilian municipalities is still mostly in-person and episodic, often delivered by state government schools, the National Industrial Apprenticeship Service (SENAI), the National Commercial Apprenticeship Service (SENAC), or external consultants hired on an ad hoc basis [11]. The model has its strengths, especially the direct interaction between instructors and participants, but it also runs into structural limits around scalability, accessibility, and the ability to meet individualized learning needs.

The fieldwork in Fraiburgo and Florianópolis showed that, when training is offered, it tends to cluster around specific events, usually triggered by new legislation coming into force or by operational failures that have already started to impact services. The logic is reactive: training comes after problems happen, not as a proactive way to build capacity, which would let resources be directed earlier and more efficiently.

Machine Learning techniques process student interaction data to identify learning patterns, evaluate how effective the instructional model is, and inform design improvements. These applications of learning data analysis include data mining, knowledge discovery, and trajectory modeling.

Natural Language Processing (NLP) provides the mechanisms behind several advanced adaptive features, including automated assessment of constructed responses, personalized feedback, and conversational dialogue support. NLP-based systems have shown they can deliver detailed instructional feedback comparable to that of human evaluators.

Combining multiple ML techniques in adaptive training platforms makes a sophisticated form of personalization possible, one that takes into account several dimensions of individual difference, including the student's prior knowledge, learning preferences, motivation, and situational constraints. Even so, effective implementations require relevant training data, careful model validation, and attention to ethical issues around data privacy and algorithmic fairness.

III. Methodology

Research Characterization

This research is exploratory-descriptive, with a qualitative approach, and uses the case study strategy as defined by Yin [13]. Choosing two municipalities of different sizes (Fraiburgo and Florianópolis, both in Santa Catarina) made it possible to analyze contrasts between contexts of small and medium administrative capacity, which strengthens the external validity of the findings.

Participants

Inclusion Criteria

Public servants currently in active service in Fraiburgo and Florianópolis, with at least two years of experience in the public sector, who took part in any training program offered by the municipality between 2022 and 2024.

Exclusion Criteria

- a) Servants with less than two years of experience in the municipality;
- b) Absence of previous experience in professional training programs;
- c) Servants on leave or absent during the data collection period;
- d) Refusal to participate in the research or to authorize the recording of interviews.

Data Collection Procedures

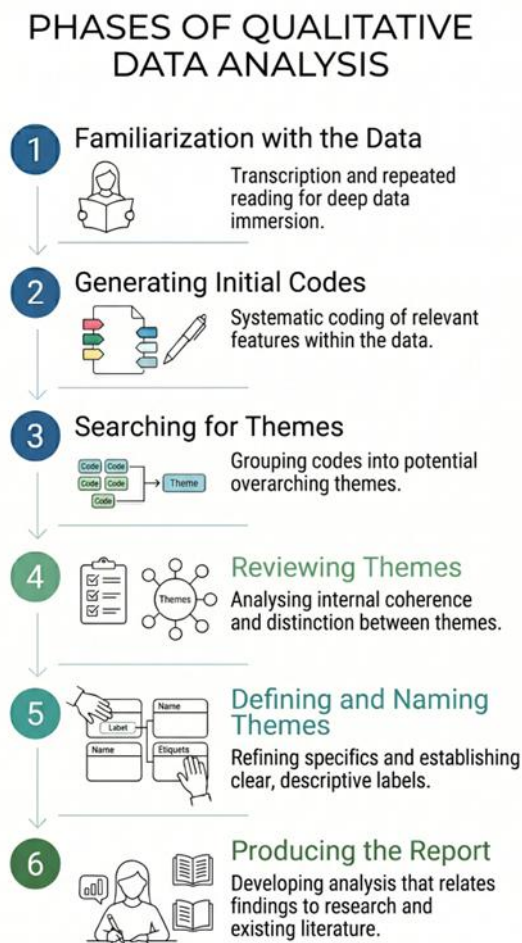
Interviews were carried out in person at each participant’s institution, in a reserved environment and during work hours, with prior authorization from immediate supervisors. Each interview lasted on average 45 minutes and was fully recorded in audio with the participant’s consent.

Data collection ran from March to May 2024, scheduled in advance according to participant availability. The same researcher conducted all interviews, which kept the script and the conduct of the interactions consistent. The instrument was a semi-structured script, designed from the research objectives and the literature in the area, which allowed both standardization of the topics and the flexibility needed to follow up on issues that came up during the conversation. Alongside the interviews, a 5-point Likert scale was used as an auxiliary quantitative instrument inside this qualitative design, to measure the intensity of participants’ perceptions about the training criteria under evaluation. The intent was not statistical generalization but stronger interpretive rigor through triangulation between the qualitative findings of the interviews and the descriptive patterns of agreement and disagreement captured by the scale, which adds consistency to the analysis without changing the qualitative nature of the study.

Data Analysis

Data were analyzed using the reflexive thematic analysis technique proposed by Braun and Clarke [14], following the six phases the authors set out:

Figure 01 – Phases of Qualitative Data Analysis. Source: Elaborated by the author (2026).



Ethical Aspects

The research followed all ethical procedures required for studies involving human beings, including obtaining the Free and Informed Consent Term (TCLE) from every participant. Participants’ identifying data were preserved through generic codes (E1, E2, E3, etc.), and the audio recordings were stored in a secure location with restricted access for the researcher only.

IV. Results And Discussion

AI Methodologies in Adaptive Training

Reinforcement Learning Approach

Current implementations of Reinforcement Learning (RL) in adaptive training rely on several algorithmic architectures, such as Q-Learning and Deep Q-Networks. These methods are essential for learning the action value functions that project the expected rewards for different instructional strategies applied to students. Training systems built around the Deep Q-Network (DQN) method have shown they can “learn” the best ways to teach in complicated scenarios. They do this by analyzing the high-dimensional information that represents the students [9].

Reddy et al. [15] argue that these approaches directly optimize the parameterized instructional policies used in training models, which makes lighter adaptations possible while having a strong effect on engagement and retention. They also show that policy gradient methods can personalize content selection effectively, sequencing and assembling pedagogical strategies based on individual student characteristics. Bandit algorithms, in addition, provide efficient frameworks to balance the exploration of new instructional strategies with the exploitation of approaches that have already been validated.

Applying RL to adaptive training has clear advantages: the system can learn from real interactions with learners, find non-obvious instructional strategies, and adjust as learning objectives evolve. The flip side is that effective RL implementations require substantial training data, careful design and testing of rewards, and attention to safety issues that come with exploratory learning strategies.

Intelligent Tutoring Systems

Intelligent Tutoring Systems (ITS) are one of the most mature applications of AI in personalized learning. They combine specialized domain modeling, learner modeling, and adaptive tutorial strategies to deliver individualized instruction and guidance [7]. Modern ITS architectures bring together several AI technologies, including knowledge representation, machine learning, and natural language processing, to build comprehensive adaptive learning environments.

Recent developments in ITS focus on incorporating advanced techniques in student modeling that use Bayesian knowledge tracing, item response theory, and deep learning methods to keep accurate, up-to-date learner models.

Another component supporting pedagogical strategies is the set of systems that select appropriate content, provide feedback, and adapt instruction based on the current student model. They can incorporate several pedagogical strategies, including scaffolding, problem-based learning, and direct instruction [16].

The interface modules manage student interactions, present content, and collect performance data. Contemporary ITS interfaces apply user experience design principles and may include gamification elements to increase engagement and retention.

The empirical evidence on ITS shows substantial efficacy across various learning domains. Meta-analyses indicate that well-designed ITS can produce learning gains comparable to one-on-one human tutoring. In public sector training, ITS have shown the potential to provide personalized instruction in complex domains, including regulatory compliance and administrative processes.

Machine Learning for Personalization

Machine learning techniques provide the basic capacities for personalizing training experiences, since they can analyze patterns in student data and predict individual learning needs and preferences. Current ML-based personalization implementations rely on several algorithmic architectures. Recommendation Systems, for example, apply content-based collaborative filtering to suggest appropriate learning resources based on past interactions and on similarities with other learners. Recommendation systems have proven effective in large-scale learning environments where extensive content libraries demand personalized curation [17].

Machine learning models can predict learning outcomes, identify students at risk of failure, and inform proactive intervention strategies. These predictive applications include dropout modeling, performance prediction, and identification of students who would benefit from additional support [10].

Clustering and segmentation techniques add another layer. Unsupervised learning algorithms identify groups of similar students or learning patterns, which makes segment-based personalized approaches to instruction possible.

Specific Competency Requirements

As noted earlier, Brazilian municipal public servants need to develop competencies that cover financial and budgetary management, regulatory compliance, digital technologies, and direct service to citizens. The growing complexity of public administration, especially in relation to newer regulatory structures such as the LGPD and digital government initiatives, has added training demands that overload existing systems.

Comparative Analysis: AI-Based Adaptive Training and the Needs of Brazilian Municipalities

Drawing on the data collected through interviews with public servants and on the application of the Likert scale (Table 1), the relevant criteria for the needs analysis were organized according to the means recorded in the field research.

Table no 1: Results in Likert scale by municipality and implications for adaptive platforms. Source: Author, 2025.

Evaluation Criterion	Fraiburgo (Likert)	Florianópolis (Likert)	Implication for Adaptive Platforms
Difficulty in finding specialized local competencies	5.0	5.0	Reinforces need for platform independent of local instructor
Gap between theory and practice	5.0	4.8	Requires contextualized content applied to administrative daily life
Recurrent doubts in practice after training	5.0	4.3	Indicates need for continuous post-training support
Time and resource restriction for training	5.0	Moderate	Favors consumable microcontents in short intervals
Concentration of practical knowledge in experienced servants	5.0	4.5	Demands modules of externalization of tacit knowledge
Institutional resistance to remote training	4.0	3.5	Indicates need for change management and gradual sensitization

The results above were systematically analyzed and organized according to the means recorded on the Likert scale applied during the field research.

Alignment of AI Capacities with Training Needs

Among the research results, the criterion “difficulty in finding specialized local competencies” received the maximum score (5.0 on the Likert scale) in both municipalities, regardless of size and administrative structure. This indicates that the scarcity of specialized technical support is not exclusive to small municipalities; it is a structural condition that runs across the Brazilian municipal executive. In line with this finding, Wilhelm [18] points out that Brazilian municipalities have historically turned to government schools and external partnerships to fill gaps they cannot cover internally — a strategy that has its merits but runs into limits of scale, regularity, and fit with the local context.

A second point of alignment is the lack of locally available specialized technical support, the criterion that reached the maximum mean in both municipalities. AI-based adaptive training platforms operate autonomously, without requiring instructors or qualified professionals to be physically present. The role of the human specialist shifts from delivering content to curating and validating the knowledge domains that feed the underlying models, and that work can be done remotely and at scale [3]. For municipalities that lack specialized local technical staff, this is a meaningful structural advantage.

V. Discussion

Opportunities for AI-Based Adaptive Training in Brazilian Municipalities

The main contribution of this study is to show that the problem of municipal training in Brazil is not only one of insufficient course offerings; it is the inadequacy of the available training models to the real conditions under which small municipalities operate. The theory-practice gap, the doubts that linger after training, and the concentration of tacit knowledge among experienced servants are not failures that more in-person courses in the traditional format can correct. They are symptoms of an instructional model that does not produce applied competence. AI-based adaptive training platforms attack precisely that layer of the problem, replacing the logic of one-off course delivery with content that adapts through continuous cycles of evaluation and individualized reinforcement.

The alignment found between what these platforms can do and what the interviewed municipalities need suggests that there is a viable entry point for pilot initiatives. Municipalities with more developed administrative structures, such as Florianópolis, have the infrastructure and management conditions to absorb initial implementations with lower operational risk. The institutional learning accumulated in those pilots, technical and pedagogical alike, can then sustain expansion to smaller municipalities such as Fraiburgo, where the constraints are tighter but the need is just as pressing, if not more so.

The model of shared content across municipalities is an opportunity for scalability that deserves the attention of managers and policy formulators. The most critical normative domains, mentioned earlier — public

procurement, fiscal management, data protection, digital government — are regulated by uniform federal legislation. A common curricular base, managed at the state level or by intermunicipal consortia, would allow the cost of developing models and instructional interfaces to be spread across a wide pool of beneficiaries. The arrangement is similar to the public consortia model already well established in other areas of Brazilian municipal management. It also draws support from the literature on the scalability of AI-based educational systems [16].

The barriers identified in this study, namely infrastructure, cold start, cultural resistance, and LGPD compliance, should not be read as definitive obstacles but as design parameters for the implementation strategy. The cold-start problem in particular can be mitigated by initial models trained with synthetic data based on the established normative domains, which lets the platform begin operations with a minimum acceptable performance while it accumulates real user interactions.

Future Directions and Recommendations

Drawing on these results, this section presents recommendations for researchers, public managers, and educational platform developers interested in implementing AI-based adaptive training platforms in the Brazilian municipal context.

From a research standpoint, future studies should advance in three directions. The first is the development and empirical evaluation of prototype AI-based adaptive training platforms configured specifically for municipal themes, testing their efficacy and efficiency in narrowing the theory-practice gap compared to in-person modalities. The second is investigating the organizational factors that influence technological acceptance by servants, with attention to the variations across municipalities of different sizes and geographic locations. The third is the analysis of governance models for shared development of municipal models, examining their viability and sustainability.

VI. Conclusion

This article started from two central questions. What are the technical capacities of AI-based adaptive training platforms that are relevant to the reality of municipal public servants in Brazil? And what are the main opportunities, challenges, and factors to consider when implementing AI-driven adaptive training in small Brazilian municipalities?

The systematic comparison between the international literature on AI applied to adaptive training and the empirical evidence collected in Fraiburgo and Florianópolis allowed both questions to be answered in substantive terms. From a technical perspective, the research showed structural alignment between the capacities documented in the AI literature, namely reinforcement learning to optimize instructional strategies, intelligent tutoring systems for personalized instruction, machine learning for content recommendation, and natural language processing for evaluation and feedback, and the needs documented in the municipalities studied.

The opportunities identified run through the externalization of tacit knowledge currently held by experienced servants, the offer of consumable microcontents that respect the operational constraints of municipal teams, the continuous post-training support to address the doubts that come up when servants apply the rules in practice, and the scalability of investment through governance models that operate across municipalities. The shared-content model emerges as the most promising strategy, both for distributing development costs and for building a curricular base aligned with the federal legislation that frames the work.

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