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Utilizing Big Data Analytics to Monitor Employee Progress in Training

Murali Krishna Raju Penmetsa

Principal Learning Technology Administrator, CharlesRiver Laboratories Charlotte, NC, USA
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ABSTRACT.

This article explores the potential of utilizing big data analytics in monitoring employee progress during training, driven by the growing importance of assessing professional development in modern business environments. This necessity compels organizations to implement analytical solutions for tracking educational achievements. The aim of the article is to analyze the application of big data processing methods in evaluating the effectiveness of educational programs and identifying factors that influence employee success.

The methodology is based on the study of existing data processing technologies and the use of algorithms for analyzing information about employee activities during training. The results demonstrate that leveraging data on interactions with educational platforms, test performance, and task completion enables effective tracking of progress. Applying such methods contributes to the improvement of training course content. The conclusion emphasizes that the use of big data analytics positively impacts the optimization of organizational learning processes.

The insights presented in this article will be valuable for learning and development specialists, analysts, and HR managers engaged in employee upskilling.

Keywords: big data analytics, progress monitoring, employee training, machine learning, effectiveness evaluation, HR management.

Introduction

In recent years, data processing technologies have been integrated into various business domains, including human resource management. Amid digital transformation and labor market changes, organizations face the need to optimize training processes. Traditional methods of monitoring employee learning progress rely on a limited set of metrics, which often fails to provide a comprehensive understanding of employee development and their needs. In this context, the role of big data analytics has grown significantly, offering the capability to track knowledge and skill acquisition dynamics in real time and evaluate the outcomes of educational programs.

The increasing interest in personalized approaches to learning underscores the necessity of applying big data technologies to monitor changes in employee training. Analytics enables the consideration of individual employee characteristics, the identification of challenges in material comprehension, and the adaptation of training content. The implementation of such technologies facilitates precise tracking of employee development, ensuring the flexibility of training programs aligned with shifts in external conditions. Furthermore, the application of machine learning methods and big data processing opens new opportunities to enhance training effectiveness.

The aim of this article is to analyze the application of big data processing methods for evaluating the effectiveness of educational programs and identifying factors that influence employee success.

Materials and Methods

One of the key directions in training involves the use of data analytics to enhance the effectiveness of educational processes. For instance, the study by Al Yousufi A. et al. [1] examines how data analytics aids in tracking learning progress, directly contributing to employees' professional development. The authors emphasize that data analysis technologies enable the measurement of outcomes and the prediction of career success.

The study by Pagnozzi F. [4] explores methods of applying analytics to improve employee training processes. The author asserts that integrating analytics into employee education facilitates the development of courses tailored to learners' needs, thereby boosting their productivity.

In another context, big data analytics is used to optimize organizational training strategies. The article by Khan R. et al. [2] analyzes how data is employed to evaluate the quality of human resource management systems, including employee training. The anticipated outcome of using analytics is an improvement in training program quality and alignment with organizational goals, ultimately enhancing both individual and organizational performance.

The article by Atanasijević S. et al. [3] highlights the importance of existing metrics in evaluating employees' success in accomplishing organizational tasks. The application of such methods enables the assessment of training program outcomes and the identification of areas for improvement, ultimately supporting employee development and maintaining high operational performance.

Hybrid learning formats that incorporate big data analytics have gained increasing significance in recent years. The study by Zhang H. et al. [5] examines the potential of a combined approach to employee training. This format allows for real-time progress tracking and timely adjustments to training courses, enabling responsiveness to learners' needs.

The research by Solé-Beteta X. et al. [6] focuses on automated mentoring systems capable of supporting learners throughout the educational process. These systems monitor progress, provide personalized recommendations, and ensure continuity in education.

Thus, several approaches stand out in the application of data analytics to enhance employee training quality, including the development of personalized learning pathways, strategic use of data for optimizing training processes, hybrid learning formats, and automated mentoring systems. However, certain aspects require further attention. Specifically, cultural and organizational factors influencing the adoption of analytics in educational processes remain underexplored. Moreover, there is a lack of sufficient studies examining the integration of analytics into corporate training, taking into account industry-specific characteristics.

The methodology is based on the examination of existing data processing technologies and the application of algorithms for analyzing employee actions during training.

Results and Discussion

The analysis of data in employee training involves processing both structured and unstructured information derived from interactions with platforms. Unlike methods focused on aggregated data, the Big Data approach enables working with information volumes that often go unnoticed or are challenging to analyze in detail, thereby enhancing opportunities for optimizing the educational process. In the context of employee training, essential data elements include:

- **Micro-data**: Information capturing interaction steps with the platform, such as time spent viewing materials, frequency of repeated views, and the sequence of task completion.
- **Tactile and cognitive reactions**: Parameters reflecting the speed of task completion, frequency of responses to feedback, and reactions to adaptive tasks.
- **Social interactions**: Activity on forums, participation in discussions, reviews, and evaluations from peers and mentors.

Thus, the application of data analytics for monitoring employee training represents a multifaceted process encompassing data collection, processing, analysis, and visualization. The primary goal is to assess training effectiveness, identify trends, and foster employee motivation. This is achieved using various technologies, including machine learning. Key stages of this process are illustrated in Figure 1, depicting the steps involved in the data analysis process for employee training.

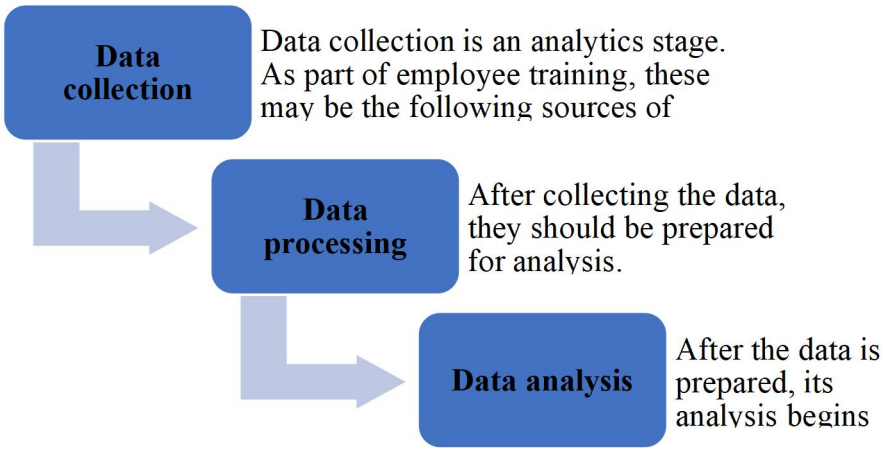

Fig. 1. Steps related to the data analysis process in the employee training process (compiled by the author).

When discussing the methods used for analyzing and processing data in employee training monitoring, it is essential to note that these methods have evolved alongside the development of technologies applied in data processing. Modern approaches, including machine learning and neural networks, provide deeper insights into employee behavior compared to traditional statistical methods. Big Data-based systems enable the identification of relationships between various parameters of the educational process, enhancing the quality of analysis and prediction. Among the primary methods used in this field, the following are notable:

- **Action sequence analysis**: This method identifies patterns in employee behavior by analyzing their actions, their sequence, and frequency. For instance, if an employee frequently revisits the same topic or task, it may indicate difficulties in mastering the material. Such behavior serves as a signal for intervention, prompting adjustments to the training process.
- **Grouping employees into clusters**: This approach segments employees into groups with similar activity characteristics. Segmentation can be based on cognitive abilities or preferences for information consumption (e.g., video lessons or text materials). This enables personalized recommendations and appropriate training formats to be offered.
- **Success prediction**: Machine learning algorithms capable of analyzing historical and current data can predict employees' success in training. This allows for the timely identification of employees who may face challenges, necessitating preventive measures to avoid difficulties, which could require additional resources.
- **Motivation assessment**: Employee activity on platforms and their interactions in social networks help form engagement profiles. Algorithms track changes in activity and detect signs of declining interest, serving as early warnings of potential motivation loss. This enables timely intervention to restore interest in training [1, 3, 5].

It is also worth noting that for analytics results to be accessible and comprehensible for HR specialists and managers, data visualization should be employed. This approach helps present complex information in a convenient and, more importantly, visually clear format. The tools used include:

- **Dashboards and reports**: Platforms such as Tableau, Power BI, and other learning solutions transform data into charts, graphs, and tables that clearly display key metrics.
- **Heatmaps and engagement graphs**: These tools enable the evaluation of employee activity in training and identification of changes in engagement, allowing for timely responses to dynamics.
- **Trend charts**: These display changes in performance, time spent on courses, and other metrics, providing the ability to track trends and address emerging issues promptly [2, 4, 6].

Various solutions are used for monitoring and analyzing employee progress in training, as illustrated in Figure 2.

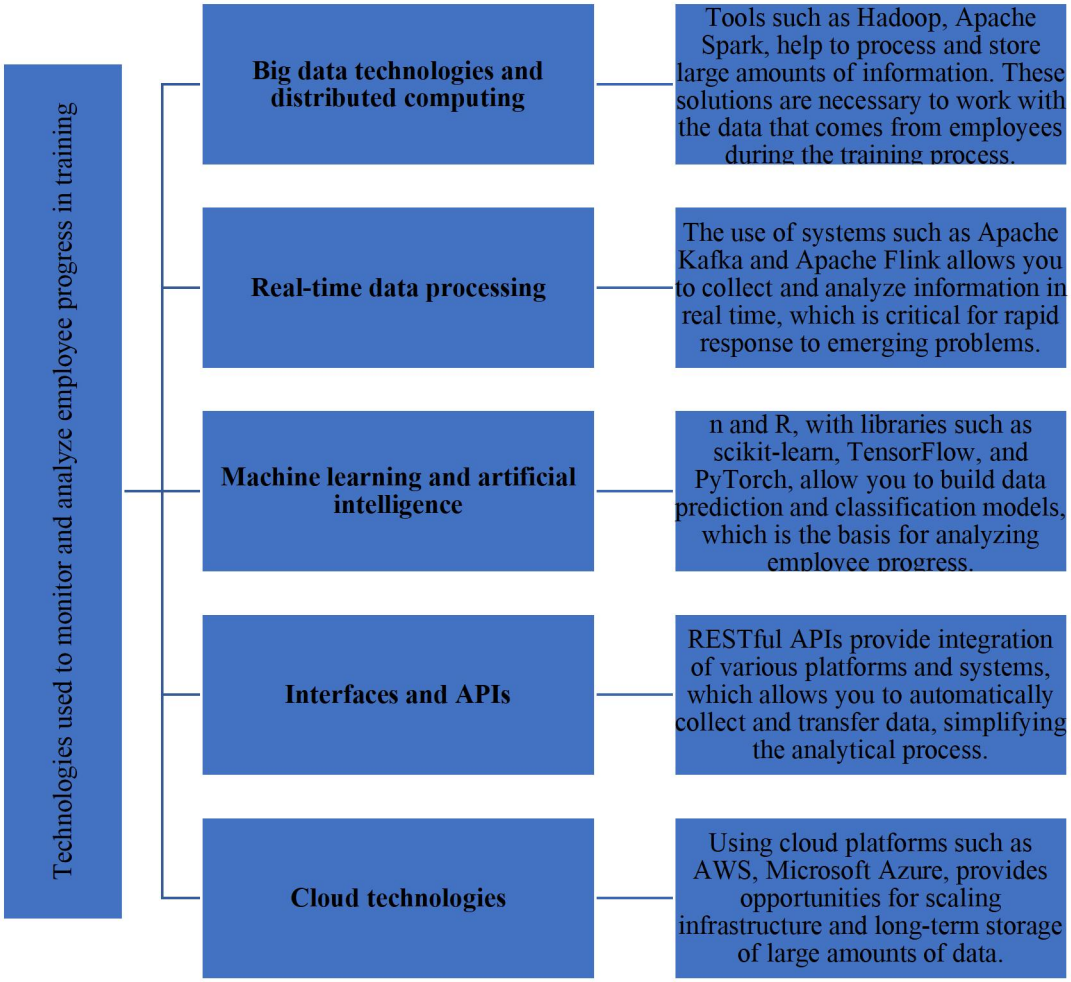

Fig.2. Technologies used to monitor and analyze employee progress in training [1, 3, 5, 6]

Analytics results are not limited to drawing conclusions; they must be integrated into workflows, which allows for the following:

- **Offering employees personalized learning paths**: For example, specific courses or tasks can be recommended to help address identified weaknesses.
- **Updating or modifying learning materials**: Based on the analysis of course effectiveness, adjustments can be made to educational materials, making courses more effective and relevant for employees in light of ongoing changes.
- **Analyzing engagement and performance**: This enables timely adjustments to training programs, thereby increasing employee engagement and improving outcomes [1, 5].

Table 1 below outlines promising directions for the use of big data analytics in monitoring employee progress in training.

Table 1. Promising areas of using big data analytics to monitor employee learning progress [1-3,5]

Area	Description	Examples of Application	Implementation Features	Role in Work Processes
Behavior Analysis in Learning Systems	Use of analytics to monitor employee activity in online courses and learning platforms.	Analysis of clicks, time spent on lessons, and interactions with materials.	Requires integration with Learning Management Systems (LMS) and subsequent configuration of key metrics.	Tracks employee activity in training and identifies signs of low engagement or difficulties in understanding material.
Progress Tracking	Analyzing employee data across groups to identify trends and differences in progress.	Comparing results of different employee groups by time, courses, or learning methods.	Requires data collection on characteristics such as experience, position, and training type.	Supports decisions about adjusting training programs based on success rates across employee cohorts.
Performance Metrics for Training Effectiveness	Applying data to analyze the relationship between training and changes in employee performance.	Comparing employee performance before and after training and analyzing KPI changes.	Requires synchronization of training data with employee performance indicators.	Provides timely feedback on how training impacts work outcomes, enabling course adjustments when needed.
Learning Success Prediction Based on Big Data	Predicting successful program completion for each employee using prior data.	Utilizing machine learning models to assess the likelihood of successful course completion.	Requires sufficient data for training models and adapting them to employee characteristics.	Assists in risk management and proactive support for employees facing challenges.
Learning Path Analysis Using Knowledge Graphs	Using knowledge graphs to analyze and visualize employee learning paths.	Developing models to track course progression and frequently studied topics.	Requires integration with learning platforms and visualization tools.	Identifies patterns in employee behavior, optimizing course structure and improving user experience.
Employee Engagement Analysis via Social Networks	Applying data analytics to evaluate employee engagement through social media activity.	Analyzing discussions, comments, and interactions in training-related forums and chats.	Requires tools for collecting and analyzing data from corporate platforms.	Identifies topics of interest, common issues, and opportunities to improve training content and formats.
Analyzing Changes in Learning Preferences	Monitoring shifts in employee learning preferences and identifying new trends.	Tracking emerging popular topics and changes in preferred training formats.	Requires continuous updates on training trends and employee needs.	Enables timely adaptation of training programs to maintain relevance and employee interest.
Correlation Between Learning and Career Growth	Analyzing the relationship between employee training levels and career achievements.	Assessing the impact of training program completion on career advancement.	Requires processing data on employee career progression.	Informs talent management decisions and provides objective data on the effectiveness of training programs in career contexts.

The application of data analytics in monitoring employee progress enables not only tracking achievements but also tailoring the educational process to specific needs. This ultimately offers opportunities to optimize educational processes, enhance their effectiveness, and create personalized learning pathways, contributing to employee growth and improved organizational outcomes.

Conclusion

In conclusion, the study explored the potential of data analytics for monitoring employee progress in educational programs and its impact on the effectiveness of organizational training processes. The analysis of modern data processing technologies, including machine learning and employee activity tracking on educational platforms, demonstrated that the use of big data enhances the accuracy of knowledge assimilation assessment and ensures timely decision-making. These methods enable the tracking of outcomes, forecasting skill development, and identifying learning difficulties at early stages.

Data analytics facilitates the personalization of educational trajectories by adapting content to the needs and characteristics of each employee. This approach improves the learning process, enhances employee motivation, and increases work productivity. The application of these tools empowers employees to make informed decisions based on extensive data insights. Moreover, the integration of these technologies into personnel management practices allows organizations to adapt to changes in the market environment and supports the professional growth of employees.

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