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Integrating Game Theory and AI in Management Training: A Revolutionary Approach to Enhancing Leadership and Managerial Decision-Making Skills

Marko Kesti

Department of Administrative Sciences, University of Lapland, Rovaniemi, Finland
Email: marko.kesti@ulapland.fi

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Abstract

The evolving global business landscape demands innovative management training to equip leaders with the agility and strategic insight needed for human-centric challenges. This paper presents a novel training methodology that combines Game Theory and Artificial Intelligence (AI) to enhance leadership and decision-making skills. By leveraging Game Theory, we dissect organizational decision-making processes, highlighting the interdependence of managerial practices and their impact on organizational dynamics. AI is employed to simulate complex decision-making scenarios, providing tailored feedback and strategic advice through advanced algorithms and data analytics. This integration creates an immersive learning environment where leaders can experiment and observe the consequences of their decisions in real-time, thereby refining their strategic thinking. At the core of our methodology is an AI-assisted simulation game that models a year in the life of a team leader, challenging players with real-world managerial dilemmas. Developed using the Unity 3D engine, the game incorporates evidence-based rules and an AI Assistant that offers real-time feedback to optimize decision-making for future rewards. A case study involving 122 university students and an organizational case study demonstrates significant improvements in strategic management understanding and decision-making skills. The application of this methodology in the Lapland Hospital District (LSHP) led to measurable enhancements in Quality of Work Life (QWL) and leadership perception, alongside a substantial return on investment. In conclusion, the integration of Game Theory and AI in management training offers a revolutionary approach to developing managerial skills, promising to reshape leadership training for the modern era.

Keywords

Management Training, Game Theory, Artificial Intelligence (AI), Leadership Development, Leadership Simulation, Simulation Learning, Performance Improvement, AI-Assisted Learning, Management Simulation Games, Strategic Management Education

1. Introduction

In the ever-evolving landscape of organizational leadership, the demand for innovative management training tools has never been more pressing. As companies navigate the complexities of the modern economy, the traditional models of training and development are increasingly seen as inadequate for preparing leaders to face the dynamic challenges of the workplace (Bersin et al., 2016). There is a growing recognition that new methodologies are necessary—ones that can simulate the unpredictable nature of business and instill the strategic agility required for effective human capital management (Fleetwood & Hesketh, 2010; Kesti & Syväjärvi, 2015).

Game theory serves as a powerful framework for dissecting the complex decision-making processes within organizations. This field of study scrutinizes the interdependent nature of choices made by individuals, a concept highly relevant to human capital management (Myerson, 1991; Osborne & Rubinstein, 1994). The decisions made by leaders and employees resonate throughout the organizational structure, influencing both performance and culture (Camerer, 2003).

By applying game theory, we can predict the outcomes of various management approaches and understand their effects on team dynamics. Such insights are crucial for enhancing employee engagement and propelling organizational success.

Alongside the evolution of strategic management theories, Artificial Intelligence (AI) is significantly redefining leadership practices. AI's emergence in the public consciousness, particularly through general language models capable of generating contextually informed advice, has been noteworthy. Yet, AI's applications extend far beyond this. Its role in enhancing learning and decision-making processes is pioneering new avenues in management training. AI employs advanced algorithms and data analysis to deliver tailored feedback, forecast outcomes, and steer leaders towards more insightful decisions. The fusion of AI with management training tools, including simulation games, cultivates an educational experience that is both interactive and adaptable, effectively mirroring the complex and ever-changing scenarios of real-world leadership challenges (Kesti et al., 2019).

As we stand at the convergence of game theory and AI, the potential to revolutionize human-centric management and leadership training is immense. This article explores the integration of these two fields, presenting an innovative ap-

proach to management training that promises to cultivate the leaders of tomorrow.

2. Game Theory in Management

The application of game theory to organizational leadership extends beyond the mere formulation of strategies; it delves into the essence of human interaction within the corporate sphere. By drawing on the principles of game theory, leaders can gain a sophisticated understanding of the incentives, conflicts, and decisions that shape the dynamics of their organizations (Osborne & Rubinstein, 1994; Camerer, 2003).

Strategic Games in management involve scenarios where the decisions of one party inevitably affect the other. Leaders must consider not only their own objectives but also the potential reactions and strategies of their counterparts, be they competitors, employees, or stakeholders. For example, a supervisor must decide whether to address an urgent matter, anticipating the possible reactions from team members and other stakeholders or the consequences of not taking the action (Kesti, 2010).

Bayesian Games address situations where decisions are made under uncertainty with incomplete information (Watkins & Dayan, 1992). In these games, leaders use probabilistic beliefs about the unknown factors to make the best possible decisions. For instance, a team leader might receive partial information about a potential market shift and must decide how to proceed based on the likelihood of different outcomes.

Stochastic Games introduce the element of randomness and unpredictability, acknowledging that not all outcomes can be controlled or foreseen (Filar & Vrieze, 1996). These games model scenarios where chance events can affect the trajectory of business operations. For example, a supervisor might plan a day for administrative tasks, but must adapt when an unexpected safety issue arises, requiring immediate attention and altering the day's plans.

Cooperative and Non-Cooperative Games examine the nature of alliances and competition. In cooperative games, the focus is on collective action and forming coalitions for mutual benefit. For instance, when a safety issue is raised, the supervisor collaborates with the team to address the problem effectively, promoting a cooperative environment. In contrast, non-cooperative games highlight individual objectives, such as when team members prioritize personal goals over collective ones (Nash, 1953).

General and Zero-Sum Games explore the distribution of gains among participants. General-sum games reflect the potential for creating value that benefits all parties, aligning with positive-sum strategies in business. For example, addressing a safety issue collaboratively can lead to improved workplace conditions and overall team satisfaction (Kesti, 2019). Conversely, zero-sum games highlight competitive scenarios where one party's gain is equivalent to another's loss, often seen in competitive market situations.

Non-Symmetric Games recognize the inherent disparities in power, information, and resources that participants may have (Harsanyi & Selten, 1988). In management, this asymmetry can be observed between different levels of an organization. For example, a team leader may have more information about company policies than team members, necessitating strategies that consider such imbalances.

Signaling Games revolve around the actions taken to reveal or conceal information. In the context of leadership, effective signaling can influence the perceptions and behaviors of employees and competitors. For instance, when a team member signals a safety concern, the leader must decide how to respond strategically—whether to address it immediately or gather more information before taking the action (Kesti, 2005).

The impact of these game theory principles on understanding management behaviors is profound. They offer a lens through which the complexity of organizational life can be viewed and interpreted. By employing these principles, leaders can navigate the intricacies of human capital management with greater clarity and foresight, leading to more informed and effective decision-making.

3. Integrating Theoretical Frameworks and Evidence-Based Deductive Rules in AI Simulation for Human Capital Management

Axelrod (1997) argues that the simulation of an agent-based model is often the only viable way to study agents who are adaptive rather than fully rational, and this seems to apply to managers and leaders as a group of agents. Our AI simulation is built upon a robust architectural skeleton formed by key theoretical frameworks (Kesti, 2019). It employs the Human Capital Production Function to elucidate the relationship between employee development and organizational output (Kesti & Syväjärvi, 2015). Furthermore, it considers the Quality of Working Life (QWL) as a critical link to performance, positing that a higher QWL directly correlates with enhanced productivity and employee satisfaction (Kesti et al., 2016).

Establishing the machine learning process for creating a reinforcement learning model, we can follow Brunton's process that includes five major stages of machine learning (Brunton, 2024). In our case, the process would have the following stages:

1) Define the Problem: The primary challenge identified is the need to enhance managerial skills to optimize the use of intangible human assets for sustained business value. The simulation game is designed to address this by providing a platform for managers to develop and refine their abilities in a controlled, risk-free environment.

2) Curate Data: Data curation in the context of the simulation involves gathering and integrating insights from real-world HR practices, employee feedback, and organizational outcomes. This data forms the basis for the scenarios within

the simulation, ensuring they are representative of true managerial challenges.

3) Design Architecture: The architecture of the AI-assisted simulation is constructed to emulate the complexities of managing human assets. It uses Unity-3D to create realistic interactions and incorporates AI to simulate employee responses and organizational dynamics, providing an immersive learning experience.

4) Craft a Reward and Loss Function: The reward function is crafted to align with the goal of improving managerial skills. Success in the game is measured by the ability to maintain or enhance the QWL while achieving financial objectives. The loss function is represented by diminished QWL or financial performance, reflecting poor managerial decisions.

5) Employ Optimization: Optimization within the game involves the use of reinforcement learning algorithms. Players are guided to make decisions that result in optimal outcomes, utilizing the feedback from the game environment to iteratively improve their management strategies.

4. Evidence-Based Deductive Rules for Simulation

The AI simulation is governed by evidence-based deductive rules that reflect well-established human asset managerial principles:

- The QWL can be systematically improved through effective managerial practices.
- The implementation of these managerial practices requires dedicated working time, acknowledging that strategic HR-Development (HRD) investments are time-consuming yet crucial.
- Societal issues within the working environment adversely impact QWL, necessitating proactive managerial responses.
- The effectiveness of managerial practices is contingent upon the proficiency with which they are executed, highlighting the importance of skilful practice deployment.
- The impact of certain managerial practices may diminish if overutilized, suggesting the need for a balanced and strategic approach to HRD interventions.
- As QWL reaches higher levels, further improvements become increasingly challenging, necessitating more nuanced and sophisticated HRD strategies.

5. AI and Machine Learning in Management Training

In the pursuit of advancing management education, we have developed a simulation learning game that adheres to the principles of game theory in management. This educational tool is designed to facilitate the understanding of the intricate dynamics of people management and its consequential impact on the financial performance of a team. The simulation leverages Unity-3D software to construct a user interface that vividly represents the emotional responses of virtual employees to managerial actions. These employees express concerns and pro-

vide feedback, serving as indicators of potential issues that may influence future productivity adversely.

Within the simulation, player behavior is guided by the chosen managerial strategy and the individual's HR competencies. Players are encouraged to interpret workers' feedback as signals, informing the selection of the most effective managerial practices to address their needs. This dynamic interplay between strategy, skill, and employee feedback constitutes a learning environment where players can experiment with different approaches, witness the outcomes of their decisions, and refine their management style accordingly.

The game introduces a variety of managerial practices available to the leader, each aimed at addressing emerging challenges and safeguarding the organization's intangible assets. However, the implementation of these practices incurs financial costs and demands the allocation of limited working hours, thereby affecting short-term profitability.

As a Bayesian game, the simulation demands strategic foresight; players must judiciously balance immediate sacrifices against anticipated long-term gains. Decision-making within this framework becomes a delicate act of optimization, where the consequences of today's choices must be weighed against their future outcomes in an uncertain environment. Leaders are afforded the opportunity to observe and analyze the consequences of their decisions in real time. The simulation model, acting as a digital twin, adeptly mimics the complexity of human behavior, bringing a high degree of realism to training simulations (Kesti, 2019). This prepares leaders for the multifaceted challenges they will face in actual managerial roles.

In the realm of management training, the incorporation of Artificial Intelligence (AI) and Machine Learning (ML) signifies a transformative leap forward. These technologies have become instrumental in capturing the subtleties of human decision-making and providing insights into the intricate dynamics of organizational leadership. An integral part of this immersive experience is the **AI Assistant**, a sophisticated feature of the simulation that guides players with data-driven advice. By tracking player decisions and outcomes, the AI Assistant offers personalized feedback and suggests alternative strategies, helping to shape more effective decision-making skills.

Underpinning the AI Assistant's capabilities is advanced algorithms like **Q-learning**, a form of reinforcement learning. Q-learning helps the AI to evaluate the potential of different actions without being explicitly programmed to follow a specific strategy. It operates on the principle of reward maximization, where each action is assigned a value based on the expected cumulative reward, known as the Q-value.

To manage the sequential nature of decision-making, **Markov Decision Processes (MDPs)** are employed, which consider the probability of transitioning from one state to another based on a particular action (Littman, 1994; Bellman, 1957). This framework is essential for understanding the stochastic nature

of managerial decision-making, where outcomes are often probabilistic rather than deterministic.

Lastly, the **Bellman Equation** (Bellman, 1957) is utilized in the simulation's AI to recursively compute the optimal policy. By breaking down the decision-making process into smaller, manageable sub-problems, the Bellman Equation allows the AI to make foresighted decisions that consider the future consequences of present actions.

By integrating these sophisticated algorithms, the AI Assistant does more than merely respond to the player's actions; it helps to shape a management style that is proactive, thoughtful, and strategically oriented towards the future. The AI's ability to balance short-term costs against long-term benefits is crucial in teaching players the value of investing in their teams and the long-term rewards of doing so (Kesti, 2021).

In sum, the AI Assistant acts as an intelligent and dynamic coaching tool, one that adapts to the user's learning curve and elevates their capacity for strategic thinking. Through its nuanced understanding of Q-learning and the Bellman equation, it provides a level of personalized mentorship that is unprecedented in management training simulations, preparing leaders to make well-informed decisions that have a positive, lasting impact on their organization.

6. Simulation Learning Game Overview

The simulation learning game, a cornerstone of this innovative approach to management training, is an intricate and engaging platform created using the Unity 3D engine. Accessible online, it provides an interactive and immersive experience that transcends traditional learning paradigms. The game cleverly gamifies the learning process, incorporating elements of reward and guidance to motivate players. It features a ranking list to foster a competitive yet educational environment where players can measure their learning outcomes against peers.

At the heart of the simulation is the replication of a year in the life of a team leader. Players step into the shoes of a manager, facing a series of employee interactions that reflect the day-to-day challenges of team management. Employees present various issues to the leader, signaling underlying problems within the team (**Figure 1**). Each identified problem is a puzzle to be solved, with the potential to cause disruptions and negatively affect the team's Quality of Work Life (QWL) index—a metric within the game that mirrors employee satisfaction and team morale in real-world settings.

Leaders are equipped with a toolbox of 31 best-managerial practices, each representing a potential solution to enhance QWL. These practices are grounded in empirical research and are designed to provide a realistic array of interventions that a manager can employ. However, the game introduces a layer of complexity by attaching a monetary cost to each practice, reflecting the real-life balance between financial considerations and the well-being of employees. Leaders must therefore navigate the delicate trade-off between investing in QWL

Figure 1. Simulation learning game user interface (https://simulation.leadermind.fi/game/bestleanboss/).

improvements and maintaining the team's monthly profit margins.

The game's sophisticated AI tracks the impact of managerial decisions on both staff QWL and the company's financial outcomes. This dual focus forces players to consider the long-term implications of their management style, making strategic decisions that balance immediate financial pressures with the ongoing need to invest in human capital. The simulation's feedback loop provides leaders with tangible results from their choices, teaching them to recognize the interconnectedness of employee well-being, team performance, and financial success.

Through this simulation game, leaders gain a profound understanding of how their actions resonate within the team well-being and fiscal performance. By directly linking managerial practices to QWL and financial metrics, the game underscores the critical role that human-centric management plays in achieving sustainable business outcomes.

7. AI Assistant's Role and Mechanism

Within the management simulation game, the AI Assistant emerges as a pivotal figure, serving as a virtual mentor to guide users through the complexities of team leadership (**Figure 2**). Its role is to observe the player's decisions, provide real-time feedback, and offer strategic advice that aligns with the principles of effective management.

The AI Assistant analyzes each action taken by the player, identifying patterns and predicting possible outcomes. It uses this information to advise on best

Figure 2. AI Assistant appears when there seems to be a need for advice. By clicking the robot figure, the Bellman function starts and the system will find the optimal recipe of managerial practices for this situation for maximizing future (12 months) profit (https://simulation.leadermind.fi/game/bestleanboss/).

practices, gently nudging the user towards decisions that not only solve immediate problems but also contribute to a healthier work environment and a more robust bottom line. This guidance is delivered in real-time, ensuring that the learning experience is continuous and responsive to the user's actions.

At the core of the AI Assistant's functionality is the implementation of **Q-learning**, an algorithm that excels in environments with a high degree of uncertainty and complexity. Q-learning enables the AI to calculate the quality, or "Q-value," of a particular action in a given state (Watkins & Dayan, 1992). This approach allows the AI to explore different strategies and learn from the outcomes, adjusting its advice as it accumulates knowledge from simulated experiences (see Figure 3).

The AI Assistant also employs the **Bellman equation** as a recursive strategy to optimize the decision-making process. The Bellman equation breaks down the journey to long-term rewards into a series of decisions made at each step, calculating the maximum expected utility for future states. This ensures that the AI's recommendations are not just reactive but are also geared towards the long-term health of the team and the financial success of the organization

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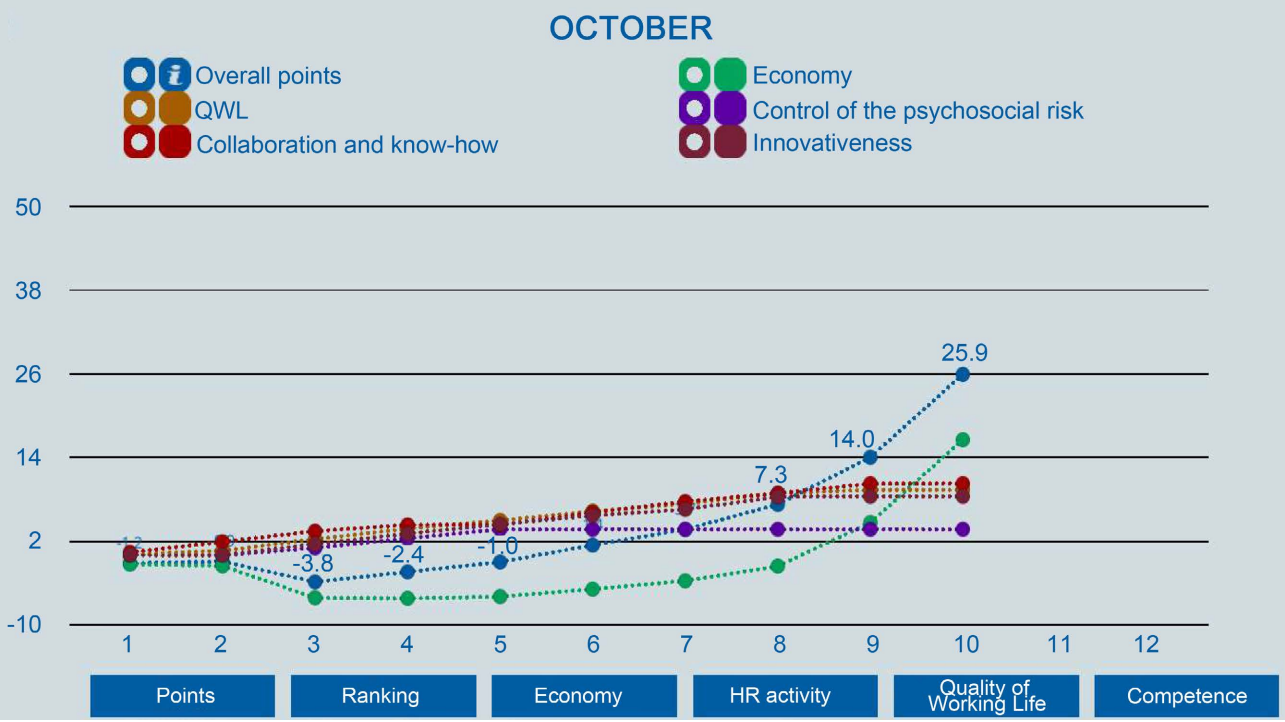

Figure 3. The simulation game draws Q-learning point (y-axis) curve along the way (months, x-axis) players learn to maximize the balance of employee well-being and profit (https://simulation.leadermind.fi/game/bestleanboss/).

players the value of investing in their teams and the long-term rewards of doing so (Kesti, 2021).

In sum, the AI Assistant acts as an intelligent and dynamic coaching tool, one that adapts to the user's learning curve and elevates their capacity for strategic thinking. Through its nuanced understanding of Q-learning and the Bellman equation, it provides a level of personalized mentorship that is unprecedented in management training simulations, preparing leaders to make well-informed decisions that have a positive, lasting impact on their organization.

8. Benefits of the Simulation Game

The AI-assisted simulation game represents a quantum leap in management training, offering several compelling advantages that cater to the evolving needs of supervisors and managers.

Accelerated Learning Curve: One of the most significant benefits is the unparalleled acceleration of the learning curve. Traditional learning-by-doing approaches, which might unfold over a decade, are condensed into a highly efficient, one-day simulation experience. This rapid learning is facilitated by the AI Assistant, which provides a continuous loop of action, feedback, and guidance, allowing managers to experience and learn from a breadth of scenarios in a compressed timeframe. This intensive, focused learning environment enables supervisors and managers to quickly assimilate complex concepts and skills that would typically take years to acquire in the workplace.

Strategic Balance Between Short- and Long-Term Goals: The simulation game excels in teaching the delicate art of balancing short-term sacrifices with long-term strategic gains (see Figure 4). Players are faced with decisions that may require upfront investments or entail short-term costs, yet have the potential to yield substantial long-term benefits. The AI Assistant is instrumental in highlighting the implications of these trade-offs, providing managers with a nuanced understanding of how today's decisions echo into the future, affecting team morale, productivity, and ultimately, the organization's financial health.

Figure 4. The strategic nature of the game is visualized by the cumulative profit (y-axis) compared to the budgeted profit for each month (x-axis) (https://simulation.leadermind.fi/game/bestleanboss/).

Enhanced Decision-Making Skills: Perhaps the most practical benefit of the simulation is the enhancement of real-world decision-making skills. By simulating realistic management challenges, the game serves as a safe testing ground for strategies and decisions. Managers can experiment, take risks, and see the consequences of their actions without any real-world repercussions. This hands-on practice in a controlled environment builds confidence and hones the decision-making skills that are crucial for effective leadership. As a result, managers emerge from the simulation better equipped to tackle complex problems and make informed, strategic decisions in their actual roles (Kesti et al., 2017).

Through these dynamic and interactive learning processes, the simulation game stands out as a tool that not only educates but also transforms the approach and capabilities of managers. It's not just about learning what to do, but also understanding the deeper principles of why certain actions work and how to think strategically, which is invaluable in the fast-paced world of modern management.

9. Case Study: AI Optimization in Management Training Simulation

A case study involving 122 university students who engaged with a management

training simulation game has yielded insightful data on the learning process. The students' performance, as measured by Q-learning points, formed an S-curve typical of a learning progression, with an average score of 29 and a median of 31 on a scale from −62 to 86 (Figure 5). This indicates a promising but varied uptake of the game's strategic management principles.

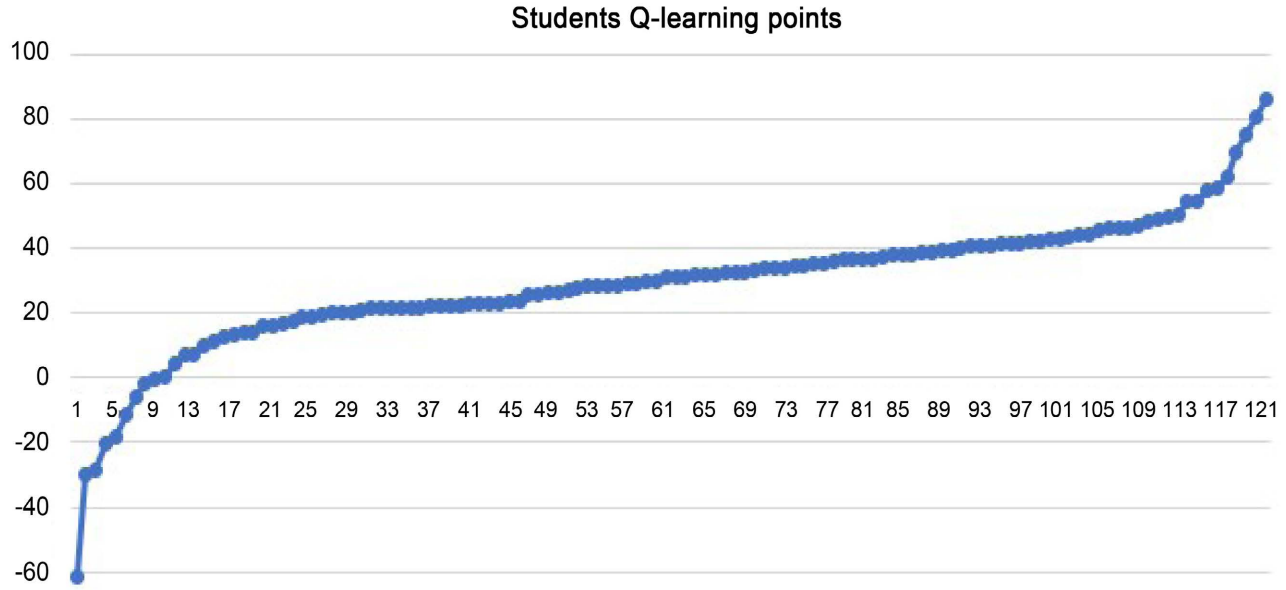

Figure 5. University students' Q-learning points (y-axis). The x-axis represents the students' simulation rounds in the order of their Q-learning points.

However, the most striking result emerged when the simulation was run using an AI optimized with the Bellman function. The AI achieved a Q-learning score of 102, surpassing the possible human range. This finding not only demonstrates the AI's ability to optimize decision-making to theoretical perfection but also sets a new benchmark for educational outcomes in management training.

This AI's performance serves as an aspirational standard, highlighting the potential of AI as a pedagogical tool. By dissecting the AI's decision-making process, educators can offer students a clear model of optimal strategies and behaviors to emulate. Moreover, the discrepancy between human and AI scores provides a unique opportunity to examine the divergence between human intuitive learning and AI's rational optimization strategies.

The case study suggests that an integration of AI-assisted decision-making can be instrumental in enhancing management training outcomes. It advocates for a symbiotic relationship where AI-derived insights complement human judgment, combining rational strategic planning with creative and emotionally intelligent leadership. Moreover, this case underscores the potential real-world applications of AI in management roles. The superior performance of the AI in the simulation implies that similar AI tools, when deployed in actual managerial contexts, could significantly enhance decision-making and organizational outcomes.

In conclusion, the application of AI in management training simulations is not merely a theoretical exercise; it is a demonstrable enhancement to the learning experience. The evidence from this case study suggests a future where AI-assisted learning is an integral component of cultivating adept, strategically minded leaders.

10. Quantifiable Impact of Simulation Learning Games in Organizational Development: The LSHP Case Study

The Lapland Hospital District (LSHP) implemented a simulation learning game in their supervisory training program, yielding significant measurable results that highlight the effectiveness of this innovative approach in organizational development.

11. Measured Results and Training Effects

Quality of Work Life (QWL) Improvement: Teams led by supervisors who completed the simulation game showed an improvement of 4.9% in the QWL index. This improvement is particularly significant considering that a one percentage point increase in the QWL index corresponds to about 460 € in economic benefits per employee in a social and health organization. The enhanced QWL index is attributed to reduced staff absences and turnover, as well as improved operational quality, leading to lower personnel and variable costs.

Enhancement in Leadership Perception: There was a 7.3% improvement in employees' perception of supervisory work, indicating a positive shift in leadership quality and team management effectiveness.

Certification and Completion Rates: The training program was voluntary, attracting a proactive segment of supervisors and managers. About 15% (22 psc) of all supervisors in LSHP successfully completed the simulation game, achieving certification and demonstrating a high level of engagement and skill acquisition.

12. Monetary Payback Estimate

The financial impact of these training outcomes was substantial:

The 4.9% improvement in the QWL index per team translates to a total annual economic benefit of approximately 45,080 € (2254 € per employee).

The cost of training, including the simulation game, was 850 € per supervisor, with an additional investment of 11 hours of work time valued at around 30 € per hour.

The total investment per supervisor amounted to 1180 € (850 € + 330 € for time spent).

Subtracting the training investment from the total benefits, the net economic gain per team was 43,900 € (45,080 € − 1180 €). This results in a Return on Investment (ROI) of approximately 37 times the initial expenditure. These results underscore the training program's effectiveness in improving leadership and work environment quality, and its remarkable financial return, demonstrating the value

of integrating innovative training tools like simulation games in organizational development.

13. Conclusion

QWL theory and Human Capital Production function (Kesti et al. 2016), reinforced with empirically grounded management research, enable the simulation game to portray nuanced human behavior in a controlled environment. The introduction of the AI-assisted simulation game marks a pivotal innovation in the field of management training. By integrating game theory principles with advanced AI algorithms, this tool offers a practical and profound learning experience that significantly accelerates the development of managerial skills.

The game's capacity to compress years of learning-by-doing into a single day's session represents a breakthrough in professional education, enabling supervisors and managers to rapidly enhance their strategic decision-making capabilities. Throughout the simulation, leaders are challenged to balance the immediate needs of their teams with the overarching objectives of the organization. The AI Assistant provides real-time feedback and strategic guidance, honing leaders' abilities to weigh short-term sacrifices against long-term gains. The game's immersive nature allows for a deeper understanding of the nuanced interactions between employee well-being, team performance, and financial outcomes, fostering a holistic view of organizational success.

Looking forward, the implications of this simulation game for human capital management and leadership development are substantial. As organizations continue to navigate the complexities of the modern business environment, the demand for leaders who can think strategically, act decisively, and adapt rapidly is set to grow. This simulation game stands as a precursor to a new era of management training, one that is data-driven, highly interactive, and deeply attuned to the multifaceted nature of human capital.

The future of leadership development is poised to be revolutionized by such innovative tools. By immersing leaders in realistic and challenging environments, and providing them with the analytical tools to understand and improve their decision-making processes, we can expect to see a new generation of managers who are well-equipped to lead their organizations to success in an increasingly complex and dynamic world.

In conclusion, the simulation game is not merely an educational tool; it is a transformative experience that reshapes how leaders think, learn, and act. Its continued use and its continued use and development may undoubtedly play a critical role in shaping the future of human capital management and the cultivation of world-class leadership talent.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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