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Sławomir ŚWITEK[1]

WILL SOCIAL LEARNING BE HINDERED BY ARTIFICIAL INTELLIGENCE WHEN THE LEAN SIX SIGMA MANAGEMENT CONCEPTION IS IMPLEMENTED?

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The increasing integration of Artificial Intelligence (AI) within Lean Six Sigma management practices raises critical questions about its impact on employee learning and collaboration. This study investigates whether AI disrupts traditional, experience-based, socially mediated learning or if it functions as a complementary tool that enhances continuous improvement. Three objectives guide the research: 1) to evaluate key adult learning theories – Kolb's experiential cycle, Mezirow's transformative learning, and Bandura's social learning – in the context of Lean Six Sigma initiatives; 2) to analyse AI learning mechanisms, including deep learning, backpropagation, and reinforcement learning from human feedback (RLHF), comparing them to human social learning processes; and 3) to determine the potential for a symbiotic relationship between human and AI driven learning. A mixed method approach combines a systematic literature review via ResearchRabbit with the author's two decades of Lean Six Sigma experience and a comparative analysis framework. The conceptual analysis suggests that AI has the potential to support reflective learning, simulate expert behaviour patterns, and facilitate knowledge consolidation. Importantly, these enhancements may occur without disrupting the critical reflection or collaboration essential to human social learning. The proposed conceptual framework for hybrid human – AI learning environments demonstrates that AI integration preserves essential social learning stages while offering data-driven insights. These results provide practitioners with evidence-based guidance for designing AI-augmented Lean Six Sigma programmes and suggest avenues for longitudinal field studies on hybrid learning outcomes.

Keywords: artificial intelligence, Lean Six Sigma, social learning

[1] WSB University, Department of Management. ORCID: 0009-0000-1082-3869.

1. INTRODUCTION

The extraordinary media popularity of publicly available solutions in the fields of image recognition and natural language processing in recent years also compels a systematic examination of this topic, as media reports often focus on negative or extreme examples, ignoring the everyday, gradual development of technology, and inherently lacking scientific discipline.

The social changes that technology will cause are unpredictable, because it will certainly have its impact. The example of social networks is a convincing one for such thinking – no one was anticipating their great development and widespread use.

The Industrial Revolution of the 19th century also had significant social consequences, resulting in the breaking up of the multi-generational patriarchal family, where each member was useful.

How will social learning processes be affected by implementing Lean Six Sigma? The question is pertinent because in the past, society, culture and religion served as the carriers of knowledge through the transmission of tradition from master to student, from father to son, and so forth. Nowadays, young people no longer have this kind of experience. The technology of our grandfathers or fathers is often unfamiliar to them. AI technology can be expected to impact on social learning processes in enterprise management in an era of significant changes.

Therefore, the primary research problem addressed in this study is the absence of a clear understanding of how the integration of Artificial Intelligence (AI) with Lean Six Sigma management practices might disrupt traditional, reexperienced, socially mediated learning and collaboration among employees or, alternatively, serve as a complementary tool that, when combined with human creativity and critical thinking, leads to improved and sustained organizational performance. This gap in knowledge hinders evidence-based guidance for practitioners seeking to design AI-augmented Lean Six Sigma initiatives that both preserve the essential social learning processes of continuous improvement and exploit the novel capabilities offered by AI.

2. PRACTICAL EXPERIENCES REGARDING SOCIAL LEARNING AMONG ADULT EMPLOYEES DURING THE IMPLEMENTATION OF LEAN SIX SIGMA MANAGEMENT IN AN ORGANIZATION

As noted in George (2002), considered the classic first publication on the integrated Lean Six Sigma management conception, it is acknowledged that business organizations are socio-technical structures where improving team performance ultimately transforms the performance of the entire organization and its organizational culture. Teamwork is the primary method used for implementing the vast

majority of improvements (improvement project teams, Kaizen Events, etc.). The Deming cycle (PDCA) is the standard way to learn about and execute such improvements, but it has been refined into the tool-enhanced format known as DMAIC in Six Sigma.

Improvement teams first receive specialized training in improvement techniques and methodologies. Then, through applying them creatively, they have the opportunity to repeatedly test and adapt these approaches to various business situations. As a result of these experiences and applications, their knowledge is consolidated, and this forms the basis for changes in behavior and organizational culture.

The majority of implementation studies naturally concentrate on the "hard" improvements that occur due to team efforts, such as increased material inventory turnover and a decreased defect rate. Some authors draw attention to the "soft" effects, which relate to changes in behaviours and organizational culture, when they incorporate the 'lean' component into the Lean Six Sigma management conception. Many terms that are related to learning, teamwork, increased motivation, employee creativity, leadership, and transformation appear to be indicators of implementation effects in this research group.

Table 1 consists of a brief review of studies (in accordance with the limitations of this article) that attempt to demonstrate the issue of employee learning in Lean Six Sigma implementations over the last 10 years.

Table 1. Experiential learning from lean six sigma deployments

Author(s)	Findings
Albliwi et al., 2014	Learning and knowledge creation in six sigma projects. Changing the culture of an organization means changing workers' habits, attitude and mentality to build a culture of confidence and trust.
Shokri, 2017	Statistics from 20 years of research work on Lean Six Sigma show that organizational learning is one of the top 5 topics described in publications.
Wang, 2022	The introduction of the Lean Six Sigma online teaching method (team discussion-based) to college financial management course will help improve students' academic performance and can also improve students' learning feelings, which will be of great significance for enhancing students' mastery of financial knowledge and their independent problem-solving ability.
Bagherian et al., 2023	The role of learning organization in a successful Lean Six Sigma deployment is emphasized.
Utama, Abirfatin, 2023	Lean Six Sigma methodology positively impacts various aspects of sustainability, including social and economic impacts. Positive social impacts include increased employee morale and commitment, improved working conditions, better utilization of human resources, and increased employee awareness of environmental, health, and safety issues.

Author(s)	Findings
Tan et al., 2024	Applied lean training and transformational leadership changed employee behaviours to more creative. subsequent team-based project coaching, exemplifies how advancing the staff's creative role identity can have a positive impact.

Source: own elaboration based on indicated literature.

Both the previously cited groundbreaking publications on lean management, namely, George (2002) and Womack & Jones (1996), emphasize that continuous improvement is based on practical activities, teamwork, workshops, and coaching interactions, which aligns with the theories of adult learning discussed in this article.

3. RESEARCH METHOD

Using the Research Rabbit software application was the primary method of research to understand the current state of knowledge. Among the key word chains used are "lean six sigma + social learning" and "lean six sigma + AI + social learning". ResearchRabbit provides access to a vast array of academic articles and research papers. It consolidates multiple databases to offer one of the most comprehensive scholarly databases available. This includes access to hundreds of millions of academic articles, covering more than 90% of materials found in major databases like Scopus and Web of Science. Data has been collected for the past decade.

The search returned 6 scientific papers, none of which address the problem of replacing social learning processes with AI. One of these articles indicates the possibility of using AI technology to improve data analytics or forecasting in logistics (Sood, Dhull, 2024).

The author of this paper, using more than 20 years of his experience in the Lean Six Sigma environment, reviewed the collected materials and presented several representative works that, in his opinion, best reflected the way in which the social learning of employees during the implementation of Lean Six Sigma.

The research question is included in the title of this paper: Will the implementation of AI within the Lean Six Sigma management conception hinder (or alter) social learning processes among adult employees? The question is rarely addressed in the existing literature.

In order to answer, the study aims to:

– evaluate current theories of adult social learning (including andragogy, Kolb's learning cycle, transformative learning, self-directed learning, and Bandura's social learning theory) and how these theories explain the way employees learn through social interactions during Lean Six Sigma improvement initiatives,

- analyse how AI models learn (with techniques like deep learning, backpropagation, and reinforcement learning from human feedback) and compare them to the social learning mechanisms of human workers,
- determine whether there is potential for a symbiosis between human social learning and AI-driven processes, that is, whether the use of AI can complement and enhance the human dimension of continuous improvement rather than replace it.

Accordingly, existing theories were reviewed, and comments were made on how they explain the practices and methods used during Lean Six Sigma implementations mainly to moderate the group social learning process (Kaizen events, improvement projects, group coaching sessions, etc.).

The next step was to specify and discuss the main ways in which generative AI models learn. Differences and convergences in the learning processes of adults and AI models were demonstrated using the comparative analysis method.

The final part of this paper presents the answer to the research question, other observations, and potential research directions.

4. EXAMINING THEORIES OF SOCIAL LEARNING AMONG ADULTS IN THE CONTEXT OF IMPLEMENTING LEAN SIX SIGMA MANAGEMENT

The implementation of the Lean Six Sigma conception undoubtedly involves social learning, as previously mentioned. Considering the adequacy of various theories of adult social learning for this application, the author of this study, based on many years of personal experience in implementing the Lean Six Sigma approach, made a preliminary review of the theories discussed in Merriam et al. (2007) and Merriam & Bierema (2013). Both sources are often cited, and their theories form the foundation of adult education research. Both scientists and practitioners use these works extensively, which indirectly indicates their frequent reference in scientific studies.

The theories that were initially chosen are: andragogy (Knowles, 1980), the Kolb's cycle (Kolb, 1984), transformative learning (Mezirow, 1991), self-directed learning (Knowles, 1975), social learning theory (Bandura, 1977), and motivation to learn – a major component of the Keller's ARCS motivation theory (Keller, 1987).

The following comparison criteria were developed to assess the suitability of the selected theories for describing the learning processes taking place in the Lean Six Sigma conception: the theoretical assumptions that underlie a given theory, the distinctive features of the outlined learning process, and the area of application (see tab. 2 for details).

Table 2. Comparison of social learning theories

Theory	Assumptive basics	Learning by	Area of utilization
Andragogy (Knowles)	Adults learn differently than children; they are self-directed, rely on experience, and need practical applications of knowledge.	Experience, intrinsic motivation, need for autonomy.	Professional training, adult education courses, mentoring.
Kolb's Learning Cycle	Learning through experience consists of four stages: experiencing, reflecting, conceptualizing, and active experimentation.	Direct experience, reflection, active testing.	Workshops, simulations, learning by doing.
Transformative Learning (Mezirow)	Adults learn through reflecting on their experiences, leading to changes in thinking and perspectives.	Critical reflection, prior experiences, perspective transformation.	Coaching, therapy, adult education based on discussion and self-reflection.
Self-Directed Learning	Adults plan, organize, and manage their own learning process based on their needs.	Autonomy, self-discipline, ability to manage one's learning.	Online courses, e-learning, personalized learning paths.
Social Learning Theory (Bandura)	People learn through observing others, modelling behavior, and social interactions.	Modelling, reinforcement, learning by observation.	Group learning, mentoring, coaching, educational media.
Learning Motivation Theory	Motivation (intrinsic and extrinsic) is key to effective adult learning.	Motivational factors: personal goals, rewards, recognition, need for growth.	Motivational systems in education, rewards, gamification.

Source: own elaboration based on Knowles, 1980; Kolb, 1984; Mezirow, 1991; Knowles, 1975; Bandura, 1977; Keller, 1987.

Based on experience, the practical area of application is also very important for implementing the Lean Six Sigma management conception. It has therefore been added as a comparison criterion. In terms of group work, Kolb's cycle, Mezirow's, and Bandura's theories reflect the most on the process of adult learning during the implementation of Lean Six Sigma. Improvement workshops, projects and coaching are the basis for the impact of this conception on the organizational behavior of employees. Practical applications in Lean Six Sigma make it a perfect fit for the approach, where experience, reflection and observation are crucial.

The following discussion presents a series of reflections on the subject:

– Kolb's Learning Cycle (Kolb, 1984):

The Kolb's model indicates a cyclical process of learning through experience, which includes the stages of experiencing, reflecting, conceptualizing, and actively experimenting. In the context of Lean Six Sigma, improvement workshops and coaching sessions enable participants not only to gain knowledge, but also to test new solutions practically and reflect on their effectiveness. This cycle of learning through experience is a perfect fit for practical improvement workshops and coaching sessions in Lean Six Sigma.

A closer examination of the Kolb and Deming cycles reveals their concurrent operation. The starting point is the same: in the Kolb cycle, this means collecting experimental data, and in the Deming cycle, the same data collection is done through problem analysis and planning. Both cycles have the same end goal – testing and implementing changes into reality. There is a difference between the two middle phases in both cycles. While the Deming cycle focuses on the physical testing of the hypothesis and the execution of the plan, in the Kolb cycle, the employee will analyse and reflect on the course of the experience and then draw theoretical conclusions from these observations. The Deming cycles will enrich the employees' experience and add it to the reflective Korb's learning phase.

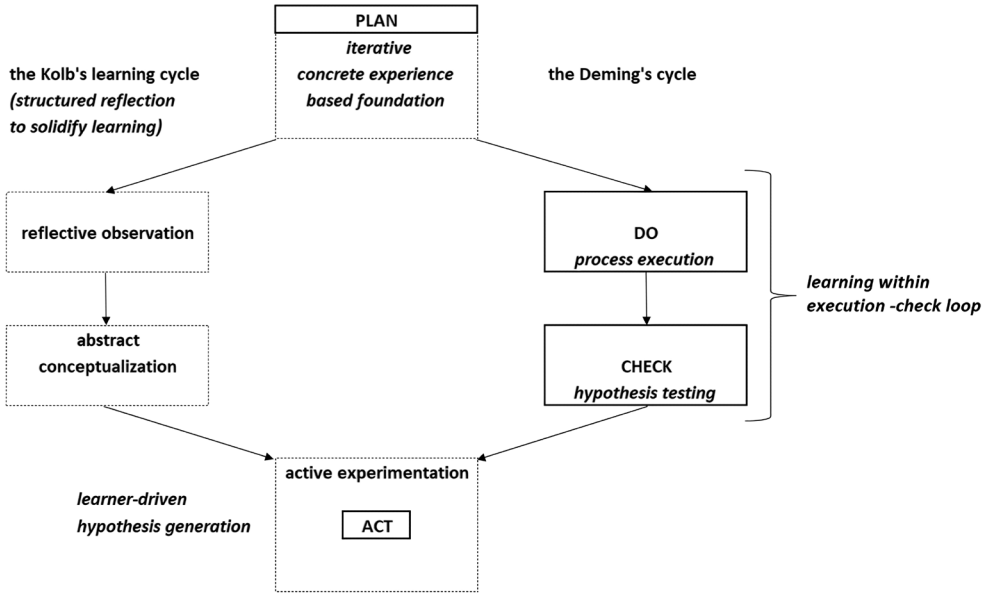

Fig. 1. The co-occurring cycles of Kolb and Deming (own elaboration)

The decision to juxtapose Kolb's experiential learning cycle with Deming's PDCA cycle in figure 1 arises from their shared iterative, experience-based foundations but distinct emphases essential to the rationale. Both models commence with either a concrete experience (Kolb) or planning phase (Deming), but Kolb prioritizes

reflective observation and abstract conceptualization, whereas Deming stresses hypothesis testing ("Check") and process execution ("Do"). By aligning them, it becomes evident that Kolb's model introduces a dedicated reflection stage before action, while Deming embeds learning within the execution-check loop. This contrast highlights how Lean Six Sigma teams benefit not only from Deming's pragmatic cycle but also from Kolb's structured reflection to solidify learning.

It is worth noting that the Deming cycle is commonly known as the learning cycle because it involves testing hypotheses, leading us closer to the solution (knowledge creation) (Milosevic et al., 2021). It is basically an improved Shewhart cycle, because Deming added the concepts of continuous improvement and learning to it (Imai, 1986).

– Transformative Learning (Mezirow, 1991):

The concept of transformation is frequently referenced in many lean implementation programmes. In the traditional sense, lean transformation means taking all the actions that will make the organization more efficient (Henderson, Larco, 1999).

In a practical study on lean, which is a representative of the new literary trend in lean management, which makes the transformation of the company dependent on changing the behaviours, habits, and attitudes of employees, the following definition can be found: "Lean fundamentally is about transforming how managers think in order to grow a business designed for constant renewal and change through continuous improvement" (Balle et al., 2017). Organically, it is a system developed by Toyota to deal with change by learning to learn.

Here is the link to Mezirow's work on learning.

As with Mezirow, transformative learning occurs when an adult takes actions that lead to a new perspective on the world. In order for this learning process to be transformational, the person must either blend their previous perspective with a new one or expand it with new experiences. This change – whether it is a completely new view or an expansion of the existing one – is what Mezirow calls transformation (Mezirow, 1996).

Through critical reflection on their previous beliefs, adults can change how they perceive themselves and the world according to the theory of transformative learning. This transformation is designed to liberate oneself from an unexamined, repetitive, and ineffective frame of reference that has been previously responsible for their life and work.

Mezirow asserts that such a change can have an impact on how people communicate with one another. In Kaizen events or process improvement teams, intense discussions can lead to a disorienting dilemma, which in turn prompts critical reflection on the issue at hand. Indeed, the improvements achieved during Kaizen events would not be possible if team members did not mentally break away from their "old" way of thinking.

Mezirow defines learning as a process in which a person utilizes their previous understanding to develop a new, improved interpretation of their experiences,

which aids in making better decisions in the future. Improvement teams implement these enhancements based on their new mental frameworks.

By synthesizing his research observations, Mezirow created a 10-stage transformative learning process (Mezirow, 2008), which is very close to what happens in business practice:

- Disorienting dilemmas. The analysis of an event can trigger a process of changing the frame of reference. The team or individuals become disoriented in their own beliefs.
- Self-insight. The consequences resulting from self-analysis (e.g. analysis of the current state in Kaizen) cause certain negative emotions, such as anxiety, shame, etc., because they are dealing here with a kind of "examination of conscience".
- Critical assessment of assumptions. The person critically assesses their previous assumptions or choices from the past. This is the beginning of a kind of dissatisfaction with past actions and how one should act in the future (new paradigm).
- Observing and accepting the co-occurrence of cognitive frustration in other people. The individual starts to acquire knowledge from others, thereby observing other individuals who are in a similar situation and are afflicted with a similar state of dissatisfaction. The individual also notices that due to cognitive dissatisfaction, someone else has undergone a transformation in their thinking. These processes are perceived holistically and have varying degrees of intensity.
- Experiencing new roles, interpersonal relationships, and actions. A reflective view of reality and rational discourse lead to the creation of new life situations and forms of action. The team experiences something new together.
- Planning further actions. People in the Kaizen team are planning further actions that are in line with their new, larger, and more flexible worldview. In a Kaizen event, this stage has a formal dimension. An action plan is approved by management, and the team begins to implement it.
- Acquiring new knowledge and skills. Through shared experience and action, people learn by acquiring specific knowledge and skills, while at the same time achieving their personal goals.
- Implementing new roles. People change their roles within the organization. Modifying their behaviour and adapting to new requirements is something they are willing to do.

The last two stages, if they occur, indicate a profound transformation. People acquire the ability to flexibly find themselves in a new reality, act confidently, and redefine their activities based on new horizons:

- building self-confidence in new roles and relationships,
- and reintegrating their own lives based on new perspectives.

In summary, the theory of transformational learning emphasizes the importance of critical reflection, which leads to a change of perspective – which reflects the

process of changing organizational behavior during the implementation of improvements. Implementing Lean Six Sigma often requires employees to rethink their current ways of doing things. Coaching and group discussions enable deep transformation, which leads to changes in assumptions and the adoption of new, more effective ways of working.

– Social Learning Theory (Bandura, 1977):

Issues related to learning from each other in improvement teams can also be seen through the lens of Bandura's social learning theory. The assumption of the theory is that a person learns by observing others' behaviour (Bandura, 1977). A special position in this concept is occupied by the model (Bandura, 1977) – the way particular people behave. Bandura's idea focuses on the relationship between two individuals – the model and the observer. The social learning theory consists of the observer repeating the behaviour that they have observed in the model. In order for the imitation mechanism to work, the following conditions have to be met:

– the observer must focus on the behaviour that is to be repeated,
– the observer must remember this behaviour,
– the observer must be able to perform it,
– and the observer must have the will and motivation to imitate.

In the Lean Six Sigma environment, group work and modelling of behaviour by experienced leaders or coaches are important elements that support the development of competencies and the adaptation of new methods of action. Ensuring that the organization has the appropriate quality of these models (which will be sensei – coaches and team leaders) to moderate and lead task groups will be of fundamental importance for the effectiveness of the implementation of the management conception.

The problem of the role of these resources in shaping desired behaviours is noted by lean practitioners (Miller et al., 2014). Without reference to the relevant theories, they address this task to leaders. At the same time, a 3-step learning process from sensei (which has its roots in industrial Japan and is used in Toyota Motor Company) is provided as a practical framework for coaches to use. These are the "shu ha ri" steps, i.e. the progression of learning various activities under the supervision of a master. At first, learning involves copying the master (shu) exactly to understand the basics. Then, one moves away from the exact copied form (ha) to adapt it to one's own needs. Finally, one goes beyond the learned form (ri) to create something unique and different (Miller et al., 2014). In these three steps, one can see a perfect convergence with A. Bandura's imitation process.

To sum up, the combination of Kolb, Mezirow, and Bandura theories provides a solid basis for comprehending how adults learn in practical applications of Lean Six Sigma. Each of these theories brings a unique perspective: from cyclical experiential learning, through deep reflection and transformation, to social-observational learning. Together, these theories create a comprehensive model for effective learning in organizations.

5. AI MODEL TRAINING PROCESSES THROUGH THE LENS OF ADULT SOCIAL LEARNING

Machine learning has made significant progress since 2017. This mainly concerns the processing of spoken language, which is implemented using models of so-called generative pre-trained transformers, where generally one matrix is recalculated by another. The past 2-3 years have seen significant breakthroughs with these tools being made public (e.g. ChatGPT). Despite public attention, ChatGPT v4 does not represent a fundamental scientific advance in model architecture. As access to GPT v. 3 and 3.5 was already there, it was known what was happening. However, few expected access to v. 4 to cause such a social stir. Therefore, what is the origin of these models?

The Google lab (Vaswani, 2017) published the most significant scientific article in the last 5-6 years, and it pertains to the attention mechanism. This is not surprising because the driving force behind what is happening in AI is not universities: it is laboratories such as Google, Meta, Amazon, OpenAI, or Microsoft. However, the impact of the attention mechanism on machine learning was not anticipated.

In general, the meaning of a word has thus far remained constant after training the model. Attention allows for some dynamics. There is a certain resemblance here to the 'semantic satiation', which pertains to natural language (Kounios et al., 2000).

A network like this, i.e. the previously mentioned transformer, has two components – an encoder and a decoder. Google (BERT)'s family of language models was created by encoders. The second module spawned decoders, and ChatGPT is exactly a decoder. The procedure for teaching such a model is to teach it with sentences or entire paragraphs; while the rest of the sentence is hidden, it predicts the next word. If it does not guess the word correctly, 'backpropagation' occurs (Cilimkovic, 2015), i.e. the weights in this model are adjusted during a lengthy training process until the next words are accurately predicted.

Models trained on large data sets have what are termed 'emergent features', namely, those that allow them to perform tasks that we did not expect them to be able to perform (Wei et al., 2022). In other words, we understand the training algorithms, but we do not know how the algorithms produced by this training work.

After initial training, the model can receive additional information to direct it to a specific domain. It can be said that the capability of the "transfer learning" characteristic in GPT-3 makes it similar to a child who first achieves fluency in everyday conversations in English and then explores more specialized areas of language, e.g. those typical for the fields of technology, computer science or even poetry (Weiss et al., 2016).

People are cognizant of their knowledge and lack thereof. GPT-3 cannot do this, which is why it sometimes generates information such as "fake news". GPT struggles with cause-and-effect reasoning. It lacks common sense and deliberate creativity as well. Moreover, it has absorbed such a huge amount of natural data from

people that it automatically acquired their biases or tendency to prejudice and malice. These shortcomings can be solved by a special learning process called reinforcement learning from human feedback (Casper et al., 2023).

To put it succinctly, we are talking about fine-tuning and human-in-the-loop training mechanisms. The backpropagation algorithms and attention mechanisms mentioned above are key components of deep learning methods, which are related to the main AI achievements of recent years.

Deep learning is one of the subfields of machine learning. It was inspired by the human brain, but it should be noted that it functions differently. Deep learning has made machines better at performing tasks, especially in the case of quantitative optimization, while people still require less data. Backpropagation in the human brain simply does not exist and AI models should be treated as Turing machines and, consequently, subject to machine learning.

Toorajipour et al. (2020) highlight the existence of numerous applications of AI for supply chain optimization. In their review, AI solutions assist managers in decision-making by analysing complex scenarios, and the authors discuss how specific AI techniques can be leveraged effectively. They also emphasize that the analytical capabilities of these technologies often surpass human performance.

In relation to the quick development of AI business applications, a systematic and comprehensive literature review conducted by Italian scientists (Sestino, De Mauro, 2021) indicates 3 areas requiring expansion in future research:

- human implications, especially in developing skills able to integrate people and AI in a synergetic ecosystem in which their interaction activates their greatest potential,
- industrial applications, strengthening the research towards technological devices and tools (such as the Internet of Things) able to support AI practices, algorithms and methods in communicating results of AI strategies, supporting data collection and becoming the peripheral object that "hosts" AI applications,
- recognition methods, spurred by the latest development of deep learning techniques described above.

From the perspective of Total Quality Management (TQM), AI serves as a key enabler of TQM digitalization across technological, process, and human dimensions. This digitized TQM, often termed Quality 4.0, encompasses:

- process-adaptive quality management, leveraging digital tools for process adjustment, real-time signal feedback, adaptive learning, and autonomous corrective actions;
- predictive quality management, in which advanced sensor technologies and powerful analytics anticipate product and process defects before they occur;
- mass personalization, inviting customers to co-design and produce individualized products at scale;
- intelligent quality management, integrating AI-driven decision support and continuous optimization to elevate overall quality performance (Liu et al., 2023).

Babashahi et al. (2024) examine the skills required for organizational transformation in the context of AI integration. Despite AI's extensive application across economic sectors, in their opinion, soft skills will remain equally crucial for future workforce success, complementing technical expertise and enabling effective collaboration, communication, and problem-solving. These skills include lifelong learning, adaptability, creativity, communication, emotional intelligence, decision-making, interpersonal skills, critical thinking, leadership, social intelligence, and physical and sensory abilities.

6. RESULTS

Table 3 outlines the numerous fundamental differences between teaching adults and AI models.

This table presents a side-by-side comparison of the learning characteristics of adult humans and AI models, highlighting fundamental differences in how each "brain" operates and acquires knowledge. AI models require vast amounts of data to achieve comparable performance, while human learners can often derive understanding from only a few data points. This contrast emphasizes the flexibility of humans versus the dependency of machine learning systems on data.

Table 3. Learning of adult vs. learning of AI models (comparative analysis)

	Human brain	AI brain (deep learning)
1. Features needed to learn	few data points	extensive dataset requirement
2. Quantitative optimization and matching (e.g. selecting one face from a million)	difficult	easy
3. Individualization depending on the situation (e.g. showing each user a different product to maximize sales)	difficult	easy
4. Abstract concepts, analytical reasoning, drawing conclusions, common sense, insight	easy	difficult
5. Creativity	easy	difficult
6. Social learning	exists	does not exist
7. Social learning theories	exist	machine learning

	Human brain	AI brain (deep learning)
8. Awareness	metacognitive awareness of knowledge gaps	does not exist
9. Empathy	exists	it doesn't have and doesn't understand feelings
10. Socialization	generational transfer of knowledge, educating young people social learning	reinforcement learning from human feedback

Source: own elaboration, points 1-4 based on Lee, Qiufan, 2021.

Human cognition is less proficient in processing and optimizing tasks that involve sifting through massive datasets. AI models are excellent at performing quantitative optimizations because of the inherent efficiency of computational algorithms in dealing with large-scale data. This capability also facilitates the personalization of digital experiences, where AI can easily individualize outputs such as delivering tailored product suggestions, for instance, something that remains more challenging for human-centric approaches.

Furthermore, the table indicates a clear divergence in the domains of abstract reasoning and creativity. Humans naturally have the ability to think abstractly and rationally, and to apply common sense, which allows them to draw meaningful conclusions from their experiences. In contrast, AI models lack the ability to grasp abstract concepts or exhibit creative problem-solving, resulting in less developed nuanced skills and a limited capability to grasp abstract concepts.

The two are further differentiated by their social aspects. Humans benefit from social learning through generational knowledge transfer, interpersonal interactions, and the development of empathy. All of these are vital for holistic cognitive development. AI, on the other hand, is not able to learn through social interactions and empathy, and instead relies on reinforcement learning and human feedback for iterative improvement. Human learning's inherently collaborative nature is highlighted by this distinction compared to the solitary, data-driven processes underlying artificial intelligence.

Recent journal literature shows that AI can augment rather than replace the social learning mechanisms central to the Lean Six Sigma when deployed with human-centric governance. AI-enabled simulations and instant analytics accelerate Kolb's action-reflection cycle in Kaizen and Playing Lean formats, improving experiential practice and rapid feedback loops (Pešec, 2022).

AI diagnostics can produce disorienting dilemmas that trigger Mezirow-style critical reflection and reframing of assumptions, but such transformative effects depend on interpretive support from coaches and teams (Escobar et al., 2023).

Algorithmic coaches and digital agents can externalize expert heuristics and model behaviours for observational learning (Bandura), yet their pedagogic value hinges on participatory implementation and employee agency (Haipeter et al., 2024).

Besides, in the context of Bandura's framework, shared leadership and psychological safety remain decisive mediators: AI tools amplify learning only when teams maintain open, co-creative practices (Wu et al., 2024).

Crucially, AI's role in lean manufacturing must maintain a human-centred balance: advanced digitalization supports social-technical learning, but only when combined with lean principles of people development and purposeful reflection (Powell, 2024).

By referencing the earlier literature review and the exploratory findings in the article, it can be clarified that the observed outcomes suggest a symbiosis rather than a displacement. This enriched analysis, limited to the concepts and examples already detailed in the article, would help bridge the gap between theory and practice and provide a more comprehensive conclusion about the role of AI in social learning within the Lean Six Sigma management framework.

7. DISCUSSION AND CONCLUSIONS

This study contributes to the literature by integrating three key adult learning theories with the evolving practices of Lean Six Sigma and artificial intelligence. It proposes a new conceptual framework for understanding hybrid human-AI learning environments in continuous improvement initiatives.

The integration of Kolb's experiential learning cycle, Mezirow's transformative learning theory, Bandura's social learning theory with reinforcement learning from human feedback (RLHF) and AI-based augmentation represents a novel contribution. Whereas prior research has examined these theories in isolation or in purely human contexts, this work demonstrates how AI can scaffold reflective observation, promote disorienting dilemmas that trigger perspective shifts, and model expert behaviours in real time, thereby enriching each stage of adult learning in organizational settings.

All three research objectives have been addressed. Firstly, this study evaluated current adult social learning theories and showed how each explains employee interactions during Lean Six Sigma initiatives. Secondly, it analysed AI learning processes – deep learning, backpropagation, and RLHF and compared them to human mechanisms of re-experience and socially mediated learning. Thirdly, it established evidence for a symbiotic relationship in which AI complements rather than replaces traditional social learning, preserving human creativity and critical thinking while delivering data-driven insights.

Accordingly, the research question of whether AI integration within Lean Six Sigma hinders or enhances social learning has been answered. The findings indicate

that AI serves as an effective augmentation tool: it accelerates knowledge consolidation and supports decision-making without disrupting the essential reflective and collaborative processes that underlie continuous improvement.

In summary, this study offers practitioners evidence-based guidance for designing AI-augmented Lean Six Sigma programmes that leverage both machine intelligence and human social learning.

Future research might operationalize the proposed framework in longitudinal field studies and examine specific AI tools' impact on team dynamics.

LITERATURE

Albliwi, S., Antony, J., Lim, S.A.H., van der Wiele, T. (2014). Critical failure factors of Lean Six Sigma: a systematic literature review. *International Journal of Quality & Reliability Management*, 31(9), 1012-1030.

Babashahi, L., Barbosa, C.E., Lima, Y., Lyra, A., Salazar, H., Argôlo, M., … & Souza, J.M.D. (2024). AI in the workplace: A systematic review of skill transformation in the industry. *Administrative Sciences*, 14(6), 127.

Bagherian, A., Gershon, M., Swarnakar, V. (2023). Identification of learning organisation key elements leading to successful implementation of Six Sigma: an empirical study. *International Journal of Productivity and Quality Management*, 38(3), 361-387.

Ballé, M., Jones, D.T., Chaize, J., Fiume, O. (2017). *The Lean Strategy: using lean to create competitive advantage, unleash innovation, and deliver sustainable growth*. McGraw-Hill.

Bandura, A. (1977). *Social Learning Theory*. Prentice Hall.

Casper, S., Davies, X., Shi, C., Gilbert, T.K., Scheurer, J., Rando, J., Freedman, R., Korbak, T., Lindner, D., Freire, P., Wang, T., Marks, S., Segerie, Ch.R., Carroll, M., Peng, A., Christoffersen, P., Damani, M., Slocum, S., Anwar, U., Siththaranjan, A., Nadeau, M., Michaud, E.J., Pfau, J., Krasheninnikov, D., Chen, X., Langosco, L., Hase, P., Biyik, E., Dragan, A., Krueger, D., Sadigh, D., Hadfield-Menell, D. (2023). Open problems and fundamental limitations of reinforcement learning from human feedback. arXiv preprint arXiv:2307.15217.

Cilimkovic, M. (2015). Neural networks and back propagation algorithm. Institute of Technology Blanchardstown, Blanchardstown Road North Dublin, 15(1), 18.

Escobar, C.A., Macias-Arregoyta, D., Morales-Menendez, R. (2023). The decay of Six Sigma and the rise of Quality 4.0 in manufacturing innovation. *Quality Engineering*, 36(2), 316-335.

George, M.L. (2002). *Lean six sigma: Combining six sigma quality with lean speed*. McGraw-Hill.

Haipeter, T., Wannöel, M., Daus, J.-T., Schaarczik, S. (2024). Human-centered AI through employee participation. *Frontiers in Artificial Intelligence*, 7, Article 1272102.

Henderson, B.A., Larco, J.L. (1999). *Lean transformation – how to change your business into a lean enterprise*. The Oaklea Press.

Imai, M. (1986). *Kaizen – the key to Japan's competitive success*. McGraw-Hill Education.

Keller, J.M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development*, 10(3), 2-10.

Knowles, M.S. (1975). *Self-Directed Learning: A Guide for Learners and Teachers*. Chicago, IL: Follett.

Knowles, M.S. (1980). *The Modern Practice of Adult Education: From Pedagogy to Andragogy*. Englewood Cliffs, NJ: Cambridge Adult Education.

Kolb, D.A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall.

Kounios, J., Kotz, S.A., Holcomb, P.J. (2000). On the locus of the semantic satiation effect: Evidence from event-related brain potentials. *Memory & Cognition*, 28(8), 1366-1377.

Lee, K.F., Qiufan, C. (2021). *AI 2041: Ten visions for our future. Crown currency*.

Liu, H.C., Liu, R., Gu, X., Yang, M. (2023). From total quality management to Quality 4.0: A systematic literature review and future research agenda. *Frontiers of Engineering Management*, 10(2), 191-205.

Merriam, S.B., Bierema, L.L. (2013). *Adult Learning: Linking Theory and Practice*. Jossey-Bass.

Merriam, S.B., Caffarella, R.S., Baumgartner, L.M. (2007). *Learning in adulthood: A comprehensive guide*. Wiley.

Mezirow, J. (1991). *Transformative Dimensions of Adult Learning*. Jossey-Bass.

Mezirow, J. (1996). Beyond Freire and Habermas: confusion a response to Bruce Pietrykowski. *Adult Education Quarterly*, 46(4), 237-239.

Mezirow, J. (2008). *An overview on transformative learning. Lifelong learning*. Taylor Francis.

Miller, J., Wroblewski, M., Villafuerte, J. (2014). *Creating a Kaizen culture: align the organization, achieve breakthrough results and sustain the gains*. McGraw-Hill Education.

Milosevic, M., Djapan, M., D'Amato, R., Ungureanu, N., Ruggiero, A. (2021). Sustainability of the production process by applying lean manufacturing through the PDCA cycle – a case study in the machinery industry. In: S. Hloch, D. Klichová, F. Pude, G.M. Krolczyk, S. Chattopadhyaya (eds.). *Advances in Manufacturing Engineering and Materials II*. Springer, 199-211.

Pešec, B. (2022). Improving the impact of remote Playing Lean workshops through action inquiry and critical reflexivity. *International Journal of Lean Six Sigma*, 14(6), 1144-1167.

Powell, D.J. (2024). Artificial intelligence in lean manufacturing: digitalization with a human touch? *International Journal of Lean Six Sigma*, 15(3), 719-729.

Sestino, A., De Mauro, A. (2021). Leveraging Artificial Intelligence in Business: Implications, Applications and Methods. *Technology Analysis & Strategic Management*, 34(1), 16-29.

Shokri, A. (2017). Quantitative analysis of Six Sigma, Lean and Lean Six Sigma research publications in last two decades. *International Journal of Quality & Reliability Management*, 34(5), 598-625.

Sood, A.C., Dhull, K.S. (2024). The Future of Six Sigma-Integrating AI for Continuous Improvement. *International Journal of Innovative Research in Engineering and Management*, 11(5), 8-15.

Tan, A.B.C., van Dun, D.H., Wilderom, C.P.M. (2024). Lean innovation training and transformational leadership for employee creative role identity and innovative work behavior in a public service organization. *International Journal of Lean Six Sigma*, 15(8), 1-31.

Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P. (2020). Artificial intelligence in supply chain management: A systematic literature review. *Journal of Business Research*, 122, 502-517.

Utama, D.M, Abirfatin, M. (2023). Sustainable Lean Six-sigma: A new framework for improve sustainable manufacturing performance. *Cleaner Engineering and Technology*, 17, 100700.

Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A.N., Kaiser, Ł. Polosukhin, I. (2017). *Attention is all you need. Advances in neural information processing systems*.

Wang, Q. (2022). Application of six sigma management-based teaching method in financial management course online teaching. *International Journal of Emerging Technologies in Learning (iJET)*, 17(1), 60-73.

Wei, J., Tay, Y., Bommasani, R., Raffel, C., Zoph, B., Borgeaud, S., Yogatama, D., Bosma, M., Zhou, D., Metzler, D., Chi, E.H., Hashimoto, T., Vinyals, O., Liang, P., Dean, J., Fedus, W. (2022). *Emergent abilities of large language models*. arXiv preprint arXiv:2206.07682.

Weiss, K., Khoshgoftaar, T.M., Wang, D. (2016). A survey of transfer learning. *Journal of Big Data*, 3, 1-40.

Womack, J.P., Jones, D.T. (1996). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Simon & Schuster.

Wu, Q., Zhou, Q., Cormican, K. (2024). Promoting shared leadership in Lean Six Sigma project teams: Toward a three-way interaction model. *International Journal of Lean Six Sigma*, 15(3), 642-663.

CZY UCZENIE SPOŁECZNE ZOSTANIE ZASTĄPIONE PRZEZ SZTUCZNĄ INTELIGENCJĘ PODCZAS WDRAŻANIA KONCEPCJI ZARZĄDZANIA LEAN SIX SIGMA?

Streszczenie

Rosnąca integracja sztucznej inteligencji (AI) w koncepcji zarządzania Lean Six Sigma rodzi istotne pytania o wpływ tej technologii na procesy społecznego uczenia się pracowników. Badanie analizuje, czy AI zakłóca tradycyjne, oparte na doświadczeniu i wymianie społecznej uczenie się, czy też staje się narzędziem komplementarnym, wspierającym ciągłe doskonalenie. Praca realizuje trzy cele: 1) ocenę kluczowych teorii uczenia się dorosłych – cyklu doświadczalnego Kolba, uczenia transformacyjnego Mezirowa i społecznego uczenia się Bandury – w kontekście inicjatyw Lean Six Sigma; 2) analizę mechanizmów uczenia się AI, w tym *deep learning*, *backpropagation* oraz *reinforcement learning from human feedback* (RLHF), w porównaniu z procesami społecznego uczenia się ludzi; 3) określenie potencjału symbiotycznej relacji między ludzkim i napędzanym przez AI uczeniem się. Wykorzystano podejście mieszane, łącząc przegląd systematyczny literatury za pomocą ResearchRabbit, dwudziestoletnie doświadczenie autora w Lean Six Sigma oraz analizę porównawczą. Analiza koncepcyjna sugeruje, że AI może wspierać uczenie refleksyjne, symulować wzorce zachowań ekspertów oraz ułatwiać konsolidację wiedzy. Co

istotne, korzyści te mogą być osiągane bez zakłócania krytycznej refleksji czy współpracy charakterystycznej dla ludzkiego uczenia się społecznego. Zaproponowano ramy koncepcyjne dla hybrydowych środowisk uczenia się człowiek–AI, wykazując, że integracja AI zachowuje kluczowe etapy społecznego uczenia się, jednocześnie dostarczając wglądu opartego na danych. Wyniki te dostarczają praktykom wytycznych opartych na dowodach do projektowania programów Lean Six Sigma z AI oraz wskazują kierunki długofalowych badań terenowych nad wynikami hybrydowego uczenia się.

Słowa kluczowe: sztuczna inteligencja, Lean Six Sigma, uczenie społeczne