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LİTERATÜR TARAMASI

Sustainable Careers for Middle-Skilled Workers in the Smart Technology, Artificial Intelligence, Robotics, and Algorithms (STARA) Era: An Overview on Upskilling and Reskilling

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Abstract

As Smart Technology, Artificial Intelligence, Robotics, and Algorithms (STARA) are becoming increasingly prevalent in work environments, significant transformations are occurring in employment relations, as well as in the methods and tools used to complete tasks. These transformations are also redefining the skills and competencies that employees are anticipated to acquire. This article focuses on middle-skilled workers, whose jobs represent a substantial portion of labor demand in global markets, making their availability crucial for economic development. Given their heightened vulnerability to the widespread adoption of STARA, upskilling and reskilling initiatives are essential for sustaining their health, productivity, and well-being. Based on sustainable career ecosystem theory, this overview presents the literature on upskilling, which enhances existing skills, and reskilling, which involves acquiring new ones, both of which are crucial elements of human resource development. It also presents the methods, approaches, and challenges within these areas, offering recommendations for upskilling and reskilling processes at the individual, organizational, and societal levels to provide career sustainability.

Keywords: STARA, sustainable career, upskilling, reskilling, human resource development
Jel Codes: J23, J24, O33

Akıllı Teknoloji, Yapay Zekâ, Robotik ve Algoritmalar (STARA) Çağında Orta Düzey Becerili Çalışanlar için Sürdürülebilir Kariyer: Beceri Geliştirme ve Yeni Beceri Kazanmaya Yönelik Genel Bir Bakış

Özet

Akıllı Teknoloji, Yapay Zekâ, Robotik ve Algoritmaların (STARA) iş ortamlarında giderek daha yaygın hale gelmesiyle birlikte, iş ilişkilerinde ve görevlerin yerine getirilmesinde kullanılan yöntemler ve araçlarda önemli değişimler yaşanmaktadır. Bu değişimler, aynı zamanda çalışanlardan beklenen beceri ve yeterlilikleri de dönüştürmektedir. Bu inceleme, küresel pazarlarda işgücü talebinin önemli bir kısmını karşılayan ve ekonomik kalkınma için kritik öneme sahip olan orta düzey becerilere sahip çalışanları ele almaktadır. STARA'nın yaygın şekilde benimsenmesine karşı daha hassas konumda olan bu çalışanların sağlık, verimlilik ve refahlarının sürdürülebilmesi için beceri geliştirme (upskilling) ve yeni beceri kazanma (reskilling) girişimleri büyük önem taşımaktadır. Sürdürülebilir kariyer ekosistemi teorisi temelinde bu incelemede, insan kaynakları geliştirmenin önemli bileşenleri haline gelen beceri geliştirme ile yeni beceri kazanmaya ilişkin literatür gözden geçirilerek bu alanlardaki yöntemler, yaklaşımlar ve karşılaşılan zorluklar tartışılmıştır. Ayrıca, kariyer sürdürülebilirliği için bireysel, organizasyonel ve toplumsal düzeyde beceri geliştirme ve yeni beceri kazanma süreçlerine yönelik öneriler sunulmuştur.

Anahtar kelimeler: STARA, sürdürülebilir kariyer, beceri geliştirme, yeni beceri kazanma, insan kaynakları geliştirme
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1. INTRODUCTION

The integration of digitalization and robotics into the workplace is recognized as the fourth stage of the Industrial Revolution (IR 4.0). IR 4.0 has significantly influenced organizational operations while also changing labor markets and national economies on a larger scale. In many industries, existing jobs have disappeared, giving rise to new roles, professions, and sectors (Brynjolfsson & McAfee, 2014). Over the next 50 years, it is predicted that every job will involve some form of robotics or artificial intelligence (Frey & Osborne, 2017). The concept of STARA, encompassing *"Smart Technology, Artificial Intelligence, Robotics, and Algorithms"*, has the potential to influence every profession that intersects with technology (Brougham & Haar, 2018). STARA is expected to lead to transformative changes in professions that still exist, necessitating workers to acquire new skills. As a result, developments in IR 4.0 have begun to profoundly affect individuals' career experiences (Hirschi, 2018). In increasingly dynamic and uncertain labor markets, career shocks have become more prevalent (Akkermans et al., 2018). To understand contemporary careers, Donald et al. (2024) introduced the perspective of sustainable career ecosystems. This conceptual framework aims to explain how individuals can sustain their careers in the face of rapid developments brought by the digital era.

Organizations are more reliant on technology for operation and competition both locally and internationally. Thus, Human Resource Development (HRD) has launched initiatives to cultivate competent personnel to current and future technological advancements for many skill levels (Germain, 2020). Middle-skilled workers refer to individuals who typically hold a vocational high school diploma or a two-year associate degree and possess technical skills. Globally, middle-skilled jobs constitute a significant portion of labor demand. In Turkey, as of 2024, certain sectors have reported a shortage of skilled intermediaries, with many companies operating with insufficient staff due to recruitment challenges (NTV, 2024). Moreover, middle-skilled workers serve as a bridge between high-skill and low-skill jobs, making them a critical component of economic development (Li, 2024). These workers are employed not only in blue-collar industries but also in administrative roles, highlighting their importance in both the manufacturing and service sectors. For associate degree graduates, upskilling and reskilling are expected to become increasingly prominent, as AI and robotics adapt more efficiently to routine and repetitive tasks (Vadie & Liptak, 2023). Notably, STARA does not affect low-skilled jobs (Brougham & Haar, 2018). Furthermore, the rise of STARA may lead to an increase in high-skill and low-skill jobs while reducing middle-skill jobs, a phenomenon known as job polarization. This trend presents a significant challenge for individuals pursuing careers in middle-skill positions, necessitating new career strategies. In this context, the growing adoption of AI in workplaces has elevated the importance of reskilling and upskilling (Ramachandran et al., 2024). Reskilling refers to transforming employees' skill sets to meet emerging needs, while upskilling involves acquiring new skills to adapt to ongoing and future changes. These processes are critical not only for organizations but also for the development of a country's human capital, particularly from a human resource management (HRM) perspective (Jaiswal et al., 2022). As STARA continues to expand, the gap between the skills employers requires and those available in the labor market has widened. According to projections by the World Economic Forum (2021), upskilling could contribute to positive employment trends by 2030.

The transformation in the careers of middle-skilled workers, who are most affected by the changes brought about by the widespread adoption of STARA, has become an important issue. Sustainable career ecosystem theory offers a wide range of practical applications for many vocational and career areas, including

the groups of employees or graduates (Donald et al., 2023). Donald et al. (2024) further recommended that the model be explored across diverse contexts. Hence, there is a requirement for assessments and recommendations that are specifically designed for individuals in middle-skilled positions and associate degree graduates. Specifically, the article considers upskilling and reskilling as micro-level components of the sustainable career ecosystem theory (Donald et al., 2024). In this context, the overview will address how upskilling and reskilling can be beneficial for middle-skilled workers from the perspective of the sustainable career ecosystem theory, focusing on individual, organizational, and social levels. This article also seeks to explore the challenges in this area and provide recommendations.

2. LITERATURE REVIEW

2.1. Smart Technology, Artificial Intelligence, Robotics, and Algorithms (Stara) And Employment

Interest in AI has experienced substantial growth in the years following Stephen Hawking's declaration that it is *"the best or worst thing to happen to humanity"* (University of Cambridge, 2016). As technological advancements and digitalization continue to reshape workplaces, their influence extends far beyond the professional sphere, affecting society as a whole. Various terms have been used to categorize these digital elements in the workplace, including "*Robotics, Artificial Intelligence, and Automation (RAIA)"* (Bharhava et al., 2021); *"Smart Technology, "Artificial Intelligence, Automation, Robotics, and Algorithms (STAARA)"* (Zhang & Jin, 2023); and *"Smart Technology, Artificial Intelligence, Robotics, and Algorithms (STARA)"* (Brooughan & Haar, 2018). Among these, STARA awareness has received particular attention in studies on employees across different industries. Some scholars argue that as STARA continues to evolve, it may not only replace human labor but also become increasingly complex, surpassing human comprehension (Fast & Horvitz, 2017). A growing body of research suggests that negative perceptions of STARA awareness can have detrimental effects on employee attitudes. For instance, Hur and Shin (2024) highlight its negative impact on proactive performance among service sector employees, while Gerçek et al. (2024) emphasize its moderating role in the relationship between employee resilience and job crafting. Additionally, several studies have linked STARA to job insecurity across various industries (Koo et al., 2021; Yücel Başer et al., 2025).

Smart technologies, a key component of STARA, encompass intelligent systems equipped with sensors, control algorithms, and control hardware, enabling them to collect data, derive meaningful insights, and drive changes accordingly (Goddard et al., 1997). According to Silverio-Fernandez et al. (2018:8), a smart device is defined as "*a context-aware electronic device capable of performing autonomous computing and connecting to other devices wire or wirelessly for data exchange."* In workplaces, smart technologies facilitate data transmission via the internet, allowing them to perform various tasks efficiently. AI refers to systems and algorithms designed to mimic human intelligence and cognitive functions such as problem-solving, learning, reasoning, perception, and decision-making (Wang, 2019; Zhang & Lu, 2021). The integration of big data into decision-making processes has further accelerated the adoption of AI in workplaces (Brynjolfsson & McAfee, 2017). In the manufacturing sector, AI is increasingly utilized across a wide range of processes, from error detection (Salehi et al., 2018) to customer analytics (Huang & Rust, 2022). It is particularly effective in handling repetitive tasks, enhancing efficiency and accuracy in various operational domains (Regona et al., 2022).

Robotics is recognized as a scientific field dedicated to synthetic machines that incorporate elements of AI (Koditschek, 2020). Robots, designed to replicate human skills, have become widely integrated into both the manufacturing and service sectors. Automation, on the other hand, focuses on designing structured environments that enhance the efficiency, productivity, and overall effectiveness of systems. It also encompasses robotic technologies, meaning that once a task becomes automatable, human involvement is no longer necessary. The impact of automation on employment was first predicted in the 1970s, with concerns that the increasing use of technological tools, particularly due to their productivity-enhancing effects, could lead to job displacement (Borodin & Gotlieb, 1972). As anticipated, automation has driven large-scale layoffs in modern companies (Reuters, 2024). Beyond automation, algorithms also play a crucial role in shaping employment. Machine learning algorithms are now widely used to process and extract insights from large datasets, enabling tasks to be completed more quickly and with fewer errors (Faraj et al., 2018). Algorithms function as structured rule sets designed for specific tasks. They are particularly effective in handling routine operations and have become a key component of STARA, influencing decision-making, marketing, HRM, and manufacturing within organizations (Burrell & Fourcade, 2021). Given their ability to analyze big data, algorithms serve as essential analytical tools. Moreover, as they continue to digitize labor markets, they are reshaping interactions between employers and employees by regulating employment processes through digital platforms (Horton, 2017). While the full extent of future developments remains uncertain, there is little doubt that STARA will have a profound impact on organizational structures and career trajectories. In this context, employees' perceptions of STARA are particularly significant, as they may face the risk of job transformation or even displacement (Brougham & Haar, 2017).

STARA awareness can function as a work stressor, as it may lead employees to experience anxiety about the impact of technological advancements on employment (Ding, 2021). This is due to the potential for STARA awareness to induce tension associated with future job security. Moreover, STARA has contributed to the rise of non-standard employment forms, such as temporary work, zero-hour contracts, and freelance work (Leitner & Sabouniha, 2024), which can further heighten perceptions of job insecurity. Negative attitudes toward STARA have been linked to increased turnover intention among service sector employees (Yücel Başer et al., 2025). From a challenge-hindrance perspective, STARA can act as a hindrance stressor, increasing employees' tendency toward job crafting (Kang et al., 2023). However, when employees perceive STARA as a challenge rather than a threat, they are more likely to develop a positive stress mindset (Yang & Jiang, 2024). In other words, while concerns about STARA are understandable, they can also serve as a motivating force, prompting individuals to take proactive steps in response to potential scenarios. Some scholars argue that STARA will not eliminate professions but will instead transform the nature of tasks within them (Chui et al., 2015). In this sense, jobs will not disappear but will undergo changes in how they are performed. Accordingly, employees can adapt to these transformations by continuously updating their skills (Pandey & Dhand, 2024). From the perspective of work adjustment theory, employees must exhibit proactive behaviors to align with changing work environments (Wang et al., 2022). As a result, upskilling and reskilling have become essential career strategies in response to job transformations (Gooptu et al., 2022). In this regard, STARA can also be viewed as an opportunity for career development from employees' perspectives (Tan et al., 2023).

2.2. Dynamic Skills and Sustainable Careers in the Era of Stara

Jaiswal et al. (2022) draw upon dynamic skill theory (Fischer & Yan, 2018) to highlight the necessity of upskilling. This theory suggests that an individual's skills are influenced by their contextual, cognitive, and emotional states, emphasizing that periods of hardship play a crucial role in skill development. From this perspective, the unexpected and challenging effects of STARA on labor markets can become key factors in shaping individuals' skill growth. These effects can pose both a threat and an opportunity for employees in their pursuit of sustainable careers (Ahmad & Bilal, 2024). A sustainable career is defined *as "the sequence of an individual's different career experiences, reflected through a variety of patterns of continuity over time, crossing several social spaces, and characterized by individual agency, herewith providing meaning to the individual"* (Van der Heijden & De Vos, 2015:7). Thus, sustainable careers focus not only on job success but also on well-being across different areas of life. It is recommended that career success be evaluated not solely through traditional measures such as financial achievement or promotions but from a sustainability perspective. This perspective expands the career concept beyond individual factors, placing it within a broader framework. Building on this idea, Donald et al. (2024) integrated the concepts of sustainable careers and career ecosystem theory to develop the *"sustainable career ecosystem theory."* This framework examines how individual careers evolve within the interconnected interactions of various stakeholders while considering individual, organizational, and societal well-being. The sustainable career ecosystem is dynamic, incorporating interrelated actors that continuously influence one another.

The key components of a sustainable career are health, happiness, and productivity (De Vos et al., 2020). A career must align with an individual's physical and mental capacities to be sustainable. When job demands exceed an individual's physical or mental capacity, it can lead to negative consequences such as pain, illness, stress, anxiety, and depression (Almroth et al., 2021; De Vries et al., 2016; Park et al., 2021). Therefore, health is the primary factor in sustaining a long-term career. Another essential component is the happiness a career provides. While happiness reflects an individual's overall satisfaction with their career, it encompasses a broader understanding of well-being compared to concepts like career satisfaction or career success. In the context of sustainable careers, happiness is associated with the alignment between personal values and career choices, the extent to which career expectations are met, opportunities for personal growth, and maintaining a work-life balance. Productivity, the third component, relates to an individual's contributions within their organization and their employability in both current and future job markets (Van der Heijden et al., 2020). In other words, productivity is a dynamic concept that reflects an individual's ability to utilize and enhance their knowledge and skills to reach their full potential.

Since STARA disrupts the concept of stable employment, the sustainable career approach, which emphasizes career continuity, offers a valuable framework for individuals (Staccioli & Virgillito, 2021). The sustainable career ecosystem perspective highlights that careers are not shaped solely by individual factors, nor should they be developed based on universally accepted standards. Given that health and happiness are also key elements, this approach addresses both individual and societal well-being. In a world where technology is constantly evolving, learning processes have become increasingly important. Today, learning agility has emerged as a crucial factor in identifying high-potential employees (Dries et al., 2012; Smith & Watkins, 2024). Defined as the *"willingness and ability to learn new competencies in order to perform under first-time, tough, or different conditions"* (Lombardo & Eichinger, 2000: 323), learning agility plays

a vital role in adapting to STARA. As STARA continuously reshapes work environments in unpredictable ways and accelerates the flow of new knowledge, employees at all career stages must continuously engage in learning. In this era, learning agility is a highly desirable trait in organizations where talent is considered a strategic competitive advantage. It enables employees to perform tasks effectively under complex conditions, collaborate with diverse individuals, remain open to new experiences, and achieve results (Dries et al., 2012). However, in organizational settings, new knowledge can render previous information obsolete. In response, unlearning, which is the process of letting go of outdated knowledge to adapt to external changes, has become a critical concept (Tsang & Zahra, 2008). Unlearning can occur at individual, team, and organizational levels (Watkins & Marsick, 2003) and involves replacing outdated systems, processes, and information with new ones. This process contributes to knowledge development and enhances adaptability (Kim & Park, 2021). As a result, in the STARA era, learning, unlearning, and relearning have become essential concepts for the workforce (Nankervis & Cameron, 2023). These processes play a key role in the productivity aspect of sustainable careers by enabling employees to develop their full potential.

Employability, as defined by Rothwell and Arnold (2007: 25), is *"the ability of an individual to enter the job they desire or continue working in their current job."* The concept of employability has gained importance not only in the labor market but also in the provision of career opportunities both within and outside organizational boundaries. McQuaid and Lindsay (2005: 208), examined the factors influencing employability across three dimensions: individual factors, personal circumstances, and external factors. Individual factors relate to the level of knowledge, skills, and abilities an individual possesses, as well as their work experience and how transferable these attributes are across different jobs. The extensive implementation of STARA has emerged as a crucial determinant affecting both the persistence of employment within an organization and transferring to another organization, owing to the changes it introduces to job processes. Studies have shown that STARA awareness increases employees' intentions to leave their jobs (Brougham & Haar, 2017), negatively affects their job commitment (Yücel Başer et al., 2025), and reduces their well-being (Oosthuizen, 2019). Bhargava et al. (2020) revealed in their qualitative study that RAIA technologies cannot replace the human touch and soft skills, and employees do not share the same attitudes toward RAIA due to their different characteristics. Conversely, not all employees perceive these technologies as a threat. Therefore, it is challenging to present a universal approach to the influence of STARA on employees' careers since differences exist on variables such as sector, organizational scale, and position level. In this regard, focusing on a particular aspect when examining the relationship between STARA and career may lead to more practical and insightful results.

2.3. Upskilling and Reskilling for Middle-Skilled Workers

The widespread adoption of STARA has led to revolutionary changes in work environments. Both the way tasks are carried out and the actors performing them have undergone transformations. Moreover, the use of robots in low-level jobs has resulted in significant layoffs (Pham et al., 2018). These developments have become a major topic of discussion in theory and practice, with research focusing on how human-technology integration can be made more humane for sustainable employment (Caliendo & Podolan, 2024; Rantanen et al., 2024). Some propose that automation will assume lower-level duties from people, but management responsibilities will be assigned to humans. This transition may prioritize conceptual skills like perception, creativity, and social intelligence

(Podgórska-Rakiel & Unterschütz, 2020). Since routine and repetitive tasks are the easiest to be transformed by STARA, middle-skilled workers are considered a significant group at risk of job loss or at least undergoing significant changes in their roles (Jacobs, 2024). Middle-skilled workers refer to individuals with *"more than a high school diploma but less than a bachelor's degree"* (Holzer & Lerman, 2017). These workers are typically skilled blue-collar workers who possess control and optimization power in production or service processes (Colombari & Neirotti, 2021). It is highly anticipated that some job tasks will be reformed, diminished, or eliminated, necessitating upskilling and reskilling to equip the current workforce to be more innovative in addressing the demands of Industry 4.0 (Li, 2020). To adapt to evolving employment and work environments, people must enhance their abilities. Therefore, for a future-ready workforce, it is essential to consider upskilling and reskilling, not only to guarantee employability but also to advance in their careers.

Upskilling refers to the process of employees developing new skills within the scope of their current job responsibilities (Li, 2024: 1706). In other words, upskilling involves increasing employees' skills through training and development in a way that allows them to adapt to changing job demands and technological advancements. It becomes particularly important when existing jobs are being performed differently, and it helps organizations fill skill gaps and increase productivity. The skill gap is defined as the mismatch between the skills employers require and those available in the workforce (Buckley et al., 2024). Furthermore, upskilling can be considered a critical resource for enabling employees to continue performing their current roles and contribute to retention. The elements of upskilling include continuous learning (Chauhan et al., 2024), adaptability, and skill development (Sawant et al., 2022). Upskilling requires a combination of both organizational and individual efforts (Vranceanu et al., 2021). To have a successful upskilling process, an organization must develop a culture focused on learning organizations and human capital development. Systematic efforts, such as adopting skill development programs and collaborating with educational institutions, are also essential for upskilling (Li, 2020). Organizational training approaches used for upskilling include industry-specific training programs (Pegrum et al., 2012), virtual reality tools (Gasteiger et al., 2021), AI-assisted training programs (Ramachandran et al., 2024), and personalized training programs (Fraile et al., 2023). Germain (2020) demonstrated that millennials, while mentoring older employees, simultaneously enhance their skills, and older employees gain new skills, thus being upskilled. Buckley et al. (2024) proposed microlearning techniques, personalized learning, flexible learning, mentoring, peer support, rewards, and recognition for upskilling, emphasizing that the process must be measured. Moreover, the concept of just-in-time learning suggests that acquiring new skills can be long-term, highlighting the importance of agility in terms of speed and flexibility in upskilling.

Reskilling refers to the acquisition of entirely new competencies beyond one's existing job domain, typically undertaken with the objective of transitioning to a different profession or sector (Sawant et al., 2022). Unlike upskilling, reskilling involves employees striving to acquire the knowledge and skills necessary for entirely new job roles (Li, 2024). Just as upskilling helps fill skill gaps and ensures organizational continuity, reskilling also enables individuals to adapt to changing job roles, supporting their transition to new career paths (Pillans, 2024). Reskilling efforts are particularly prevalent in sectors like information technology, where there is a constant demand for various skills to meet industry needs (Samuvel & Gilsha, 2023). On the other hand, industries such as manufacturing, transportation, and retail, which are dominated by repetitive, routine

tasks, are considered particularly suitable for automation. In these fields, reskilling for middle-skilled workers is considered a priority (Li, 2024). Reskilling, similar to upskilling, involves coordinated efforts from both organizations and individuals. Callan et al. (2021) identified several *"reskilling interventions,"* including large firm and supplier programs, open access programs, and customized initiatives. The study found that employees preferred more informal, fast, and practical approaches. Other methods include collaborative learning (Simões et al., 2021), work-integrated learning (Rangraz & Pareto, 2021), and online training (McKay & Izard, 2014). In Leon's (2023) study, focusing on firms in the petroleum products sector, the best tools for reskilling and upskilling were identified as *"teamwork, online communities of practice, and enterprise social networks."* In this context, both upskilling and reskilling, unlike traditional HRD practices, require more personalized, collaborative learning approaches. They also need to be less formal, long-term development-focused, and agile, reflecting the evolving demands of the workforce.

Middle-skilled workers are among the employee groups most affected by STARA-based changes (Wang et al., 2023), and upskilling and reskilling have the potential to help them respond to these transformations. Examining upskilling and reskilling for middle-skilled workers from the perspective of sustainable career ecosystem theory could involve individual, organizational, governmental, and professional association roles (Donald et al., 2024). From the self-determination perspective, the skills acquired through upskilling and reskilling can meet individuals' needs for autonomy, competence, and relatedness (Ryan & Deci, 2000). These skills, along with the potential to transition into new job roles, can enhance intrinsic motivation, positively influence workplace attitudes and behaviors, and also impact long-term well-being. Moreover, to ensure job security, middle-skilled workers need to acquire new skills that can be applied in both their current responsibilities and potential new roles. This ongoing professional development process through reskilling can facilitate workers' ability to find jobs in different areas. Upskilling, on the other hand, can enhance job security by enabling workers to maintain continuity in their current roles (Li, 2024). Both upskilling and reskilling contribute to a sustainable career for middle-skilled workers. Additionally, these processes give employees a competitive advantage in the labor market. By adapting to changes, their organizational role mobility and potential inter-organizational or inter-sector mobility may increase, thereby enhancing their adaptability (Brown & Bimrose, 2011). Increasing STARA knowledge can also improve their openness to development in this area. As digitalization within organizations expands, it leads to rapid transformation and the emergence of a digital organizational culture (Gerçek & Özveren, 2024). For instance, Ahmed and Bilal (2024) demonstrated that AI knowledge increases person-job fit, thereby enhancing career sustainability. Acquiring understanding about STARA, fostering positive attitudes, and absorbing its applications within the organization are helpful strategies.

Upskilling and reskilling at the organizational level enable employees to adapt to transformed job roles, fostering a more agile workforce (Hasan et al., 2024). Additionally, upskilling and reskilling foster the development of a more qualified talent pool by increasing employees' skills (Asiedu & Tenakwah, 2025). On the other hand, the psychological effects of individual development can increase workforce engagement levels, thereby contributing to retention. Collaborative learning and teamwork, which are often used in upskilling and reskilling processes, strengthen internal communication and promote a culture of knowledge sharing within the organization (Hasan et al., 2024; Leon, 2023). This, in turn, can contribute to creating an innovation-friendly atmosphere in the long term.

Upskilling and reskilling can contribute to reducing unemployment rates by ensuring the job security of middle-skilled workers in their current roles or facilitating their transition to new job roles, thereby generating societal benefits. In this context, a workforce prepared for the transformations or newly emerging jobs linked to STARA-driven changes can be expected (Li, 2024). This, in turn, will enable individuals to remain employed while maintaining their physical and mental health (Oluwajinmi & Adekomaya, 2023). Moreover, as upskilling and reskilling processes are also used to acquire green skills, they can contribute to sustainable development goals (Bishnoi & Rai, 2022). Research indicates a simultaneous rising need for medium-skilled workers, including positions such as technicians for renewable energy installations (Chun, 2024). In this context, upskilling and reskilling will continue to be important processes in the environmental dimension of sustainability.

3. DISCUSSION AND RECOMMENDATIONS

This study explores how upskilling and reskilling can support middle-skilled workers by increasing their existing knowledge within the framework of sustainable career ecosystem theory while also addressing the challenges involved. Upskilling and reskilling are vital processes within the domain of HRD and are essential for developing an agile workforce (Jamal et al., 2024). However, there remains no consensus on the precise scope of these processes or who should be responsible for them. Building on the sustainable career ecosystem theory, this study highlights the need for upskilling and reskilling initiatives to involve coordinated efforts at individual, organizational, and societal levels. Research on upskilling and reskilling also focuses on the methods through which these processes should be conducted and the educational strategies to be incorporated. For instance, Vrabceanu and Sutan (2020) raised the crucial question of who should bear the responsibility for upskilling. From a contract theory perspective, their study highlights the significant issue of whether the responsibility for upskilling lies with the employee or the organization. While organizations can design upskilling and reskilling programs, their successful implementation hinges on the adequacy of organizational culture, knowledge sharing, and coordination. A skilling program is defined by clearly articulating the importance of reskilling and upskilling, as well as comparing existing competencies with the new skills required (Li, 2024). Therefore, conducting skill-gap analyses should be the first step, carried out by qualified analysts and in a systematic manner. One of the main barriers to effective upskilling and reskilling is identified as inadequate HR infrastructure within organizations (Li, 2024). In other words, for these programs to succeed, HR structures must be fit for purpose, and HR experts must possess the necessary expertise. Moreover, for skilling programs to be effective, organizations must cultivate a digital organizational culture (Gerçek & Özveren, 2024), which enables a more rapid response to STARA-driven skill needs. Jamal et al. (2024) demonstrated that employees' technology acceptance and readiness for change prior to a skilling program positively influence the program's implementation. Consequently, organizational culture and HR practices are pivotal to the success of skilling programs. Furthermore, given the impact of STARA on HR roles and functions (Nankervis & Cameron, 2022), it is essential that HR departments undergo their own transformation. Thus, HR itself must integrate upskilling and reskilling into its own structure.

Various tools are employed in organizations for upskilling and reskilling initiatives. For upskilling, sector-specific training programs (Pegrum et al., 2012), virtual reality tools (Gasteiger et al., 2021), AI-supported training (Ramachandran et al., 2024), personalized programs (Fraile et al., 2023), and approaches such as microlearning, flexible learning,

mentoring, peer support, and rewards (Buckley et al., 2024) are utilized. For reskilling, effective tools include collaborative learning (Simões et al., 2021), work-integrated learning (Rangraz & Pareto, 2021), online training (McKay & Izard, 2014), and tools like teamwork, online communities of practice, and enterprise social networks in the oil industry (Leon, 2023). In addition to these methods, digital skilling (Mendoza-Chan & Pee, 2024) and designing skill-based systems (Nair et al., 2023) could also be used.

Governments play a crucial role in mitigating the impact of STARA on employment by implementing strategies that promote workforce reskilling and upskilling. These initiatives support workers affected by AI-driven automation, facilitating their transition into new job roles (Parwani et al., 2024). Li (2020) highlights the importance of collaboration between higher education institutions, government agencies, and businesses to enhance reskilling and upskilling efforts. To align vocational high schools and associate degree programs with the demands of the STARA era, curricular revisions should emphasize flexible, application-based content and training methods that reflect the evolving technological landscape. Such updates would better prepare students for the changing job market (Padmaja & Mukul, 2021). In addition, government-supported apprenticeship, internship and training programs could provide students with valuable, work-based learning experiences that could lead to acquiring essential career resources (Özer & Suna, 2022). Free courses offered through e-government platforms could further expand access to digital education, strengthening upskilling and reskilling efforts. Collaborative educational modules developed through partnerships between governments and industry sectors would also contribute to these initiatives. There is a growing consensus that the responsibility for upskilling and reskilling should not rest solely on organizations or governments but should instead be shared among multiple stakeholders (Vinayan et al., 2020). In this regard, professional chambers, trade unions, and universities could work together to design training programs that benefit all middle-skilled workers, including those entering the labor market, fostering tangible workforce improvements. At the individual level, adopting a mindset of continuous learning, unlearning, and relearning is essential for effective upskilling and reskilling strategies (Nankervis & Cameron, 2023). Recognizing skill development as a lifelong process, employees are encouraged to stay informed about industry trends, engage in professional networking, and seek external training opportunities to enhance their career prospects. Additionally, self-directed practices such as conducting SWOT analyses, career planning, and envisioning future work selves can be recommended as practical tools for advancing sustainable careers.

This study examines upskilling and reskilling for middle-skilled workers through the lens of sustainable career ecosystem theory. Since this is a literature review, it does not establish cause-and-effect relationships, and it is not possible to provide generalized information across all industries. The review highlights that middle-skilled workers are likely to be the group most affected by STARA-driven changes, but research on this group remains limited. Furthermore, studies on upskilling and reskilling are still in the development phase. Future research could explore sector-specific differences, focusing on meaningful, practical methods and their effectiveness in upskilling and reskilling for both employees and employers. Exploratory research into employees' attitudes toward the need for upskilling and reskilling as a result of STARA could provide critical insights. Additionally, training evaluation studies using quantitative and/or qualitative methods could offer guidance to many employers and bridge the gap between theory and practice for researchers. Examining the impact of upskilling and reskilling on employee productivity, well-being, and various career

attitudes may provide clearer insights into how these efforts affect sustainable careers. Given the anticipated increase in the effects of STARA in the near future, it is believed that these efforts could yield significant outcomes for middle-skilled workers. Therefore, this study is expected to provide essential information for future researchers, employers, decision-makers, HR professionals, employees, and associate degree students.

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