World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

Check for updates

Integrating human resources principles in STEM education: A review

Nancy Mohd Al Hamad [1], Ololade Elizabeth Adewusi [2], Chika Chioma Unachukwu [3], Blessing Osawaru [4] and Onyebuchi Nneamaka Chisom [5, *]

[1] *Bridge the Gap, Dubai UAE.*
[2] *Independent Researcher, UK.*
[3] *Ministry of Education, Lagos.*
[4] *International School, Benin, Edo State, Nigeria.*
[5] *National Examinations Council, Nigeria.*

World Journal of Advanced Research and Reviews, 2024, 21(01), 1174–1183

Publication history: Received on 01 December 2023; revised on 07 January 2024; accepted on 10 January 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.1.0116

Abstract

This study investigates the incorporation of Human Resources (HR) principles into STEM education, looking at theoretical underpinnings, existing models, and practical strategies. To build a conceptual foundation, the theoretical framework draws on human capital theory, organizational behavior theories, and strategic human resource management. Integration tactics include targeted recruitment, professional development, teamwork, and diversity. Recommendations span stakeholders, emphasizing educator incentives, public-private collaborations, and inclusive policy. The consequences extend to practice, policy, and research, driving the development of a diverse and talented STEM workforce. Finally, this integration marks a paradigm shift, reinventing how educators are recruited, developed, and retained to meet the changing demands of STEM areas while contributing to a technologically sophisticated and inclusive society.

Keywords: STEM education; HR principles; Integration strategies; Diversity and inclusion; Educational workforce

1. Introduction

The fields of science, technology, engineering, and mathematics (STEM), as presented in Fig 1, are crucial in determining how people will develop as individuals and as societies in the ever-changing educational landscape (Ewim, 2023; Sumarni, Sudarmin, Sumarti, & Kadarwati, 2022; Wang, Chen, Hwang, Guan, & Wang, 2022). Integrating Human Resources (HR) principles into STEM education is a transformative avenue when technological advancements and educational paradigms are converging. This integration promises to not only improve educational quality but also to equip a workforce that is capable of overcoming the challenges of the twenty-first century.

STEM education has become a cornerstone in fostering critical thinking, problem-solving, and creativity, encompassing a variety of disciplines that drive innovation and progress (Ewim, 2023; Lo, 2021). On the other hand, the dynamic nature of STEM fields necessitates an education system that goes beyond imparting technical knowledge and skills (Baran, BİLİCİ, Mesutoglu, & Ocak, 2016). It necessitates a human-centered approach that recognizes the importance of effective teaching, collaborative learning environments, and the development of well-rounded professionals (Sithole et al., 2017). Historically, incorporating HR principles has been associated with corporate settings rather than educational institutions. However, as the demand for skilled STEM professionals grows, a holistic approach that considers the human aspects of education becomes increasingly important. The application of HR principles in STEM education can help to address teacher recruitment and retention issues, promote diversity and inclusion, and improve professional development strategies, ultimately contributing to the development of a strong STEM workforce.

* Corresponding author: Onyebuchi Nneamaka Chisom

This review aims to delve into the current state of STEM education, exploring how HR principles can be effectively integrated. The objectives of this study include providing an in-depth overview of the current state of STEM education, highlighting strengths, weaknesses, and emerging trends, investigating the role of HR principles in the educational context, identifying key areas where their integration can yield positive outcomes—examining existing models or frameworks that have successfully integrated HR principles into STEM education, assessing their applicability and effectiveness and analyzing gaps and challenges in the current integration of HR principles in STEM education, paving the way for targeted recommendations and interventions.

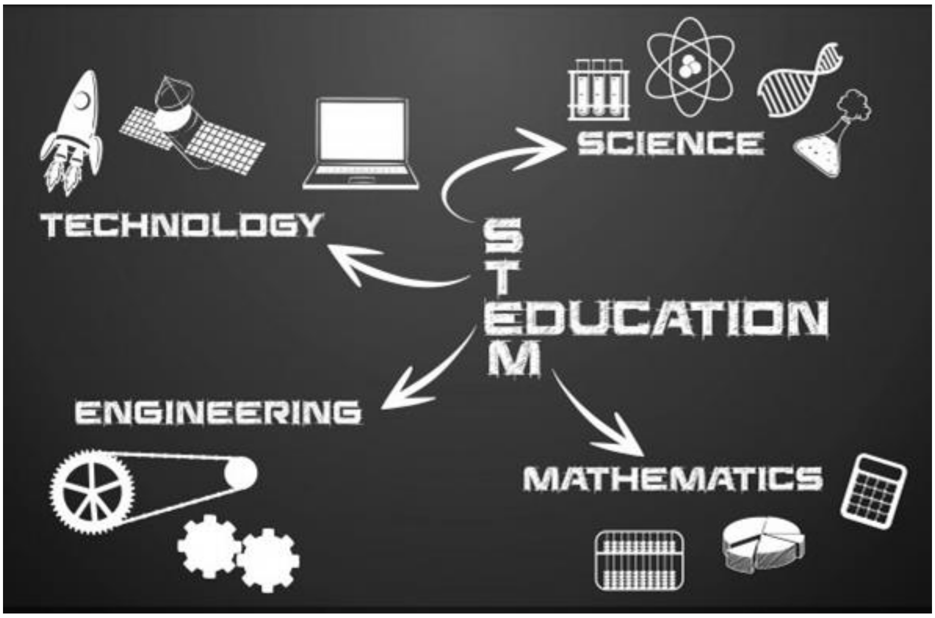

Figure 1 STEM education disciplines

This research has substantial implications for STEM educators, administrators, politicians, and researchers. It aims to contribute to a paradigm change in educational methods by identifying possible synergies between HR concepts and STEM pedagogy. Integrating HR principles into STEM education is more than just an administrative or organizational issue; it is a fundamental rethinking of how we approach the development of STEM professionals. This study's significance extends beyond the boundaries of educational institutions. It can potentially have a huge impact on enterprises, economies, and societies by developing a generation of STEM professionals with technical proficiency and exemplifying the fundamental human skills of teamwork, communication, and flexibility.

2. Literature Review

2.1. Overview of STEM Education

The landscape of STEM education is a dynamic and multifaceted domain that plays a crucial role in shaping the skills and competencies of the global workforce. The interdisciplinary nature of STEM subjects is designed to impart technical knowledge and cultivate critical thinking, problem-solving abilities, and creativity. Over the past decade, there has been a global recognition of STEM education's pivotal role in preparing individuals for the challenges and opportunities presented by a rapidly evolving technological landscape.

STEM education initiatives vary significantly across countries and regions (Bybee, 2013; Ramirez et al., 2015). Some nations focus on integrating STEM concepts into primary and secondary school curricula to foster early interest and proficiency. In contrast, others emphasize higher education and specialized training programs to meet the demands of an increasingly technology-driven job market (Aldemir & Kermani, 2017; Kelley & Knowles, 2016; Tytler, Osborne, Williams, Tytler, & Cripps Clark, 2008). The effectiveness of these initiatives depends on various factors, including curriculum design, teacher training, and the availability of resources. The global push for STEM education reflects a collective acknowledgment that proficiency in these fields benefits individuals and is crucial for national competitiveness and innovation (Olanike S, Asogwa, Njideka M, RE, & Temiloluwa O, 2023; Sharma & Yarlagadda, 2018).

Despite its acknowledged importance, STEM education faces challenges such as gender imbalances, disparities in access to quality education, and a shortage of qualified educators. The latter issue is particularly pronounced, with the demand for skilled STEM professionals outpacing the availability of qualified educators. This challenge sets the stage for exploring how HR principles can be leveraged to attract, develop, and retain talented STEM educators.

2.2. The Role of Human Resources in Education

The integration of HR principles in education represents a paradigm shift, emphasizing the strategic management of human capital to create environments conducive to effective teaching and learning (Aboramadan, Albashiti, Alharazin, & Dahleez, 2020; Kazlauskaitė & Bučiūnienė, 2008; Rafiei & Davari, 2015). Beyond administrative functions, HR in education involves talent management, recruitment, professional development, and employee engagement. In STEM education, where the demand for skilled educators is exceptionally high, HR practices become integral to cultivating a competent and motivated teaching workforce.

Strategic workforce planning is a cornerstone of effective HR in education. In the context of STEM, this involves anticipating the demand for specific skills and expertise and aligning recruitment and professional development efforts accordingly (Agarwala, 2007; Allui & Sahni, 2016). HR principles also play a pivotal role in fostering a positive and inclusive organizational culture, which is vital for attracting and retaining educators in STEM fields. Inclusive HR practices promote diversity, ensuring that STEM education benefits from various perspectives and experiences. Effective HR practices in education involve continuous professional development tailored to the evolving demands of STEM fields (Shen, Chanda, D'netto, & Monga, 2009; Shore, Cleveland, & Sanchez, 2018). This includes technical training and emphasizes developing pedagogical skills, ensuring educators effectively convey complex STEM concepts to diverse audiences. HR principles further contribute to creating collaborative learning environments, emphasizing teamwork and knowledge-sharing among educators (Sriratanaviriyakul & El-Den, 2017; Tan, 2016).

2.3. Existing Models of Integrating HR in Education

Several models and frameworks provide insight into effectively integrating HR principles into educational settings. The Human Capital Management (HCM) model, widely employed in the corporate sector, is gaining traction in education (Arokiasamy, Fujikawa, Piaralal, & Arumugam, 2023; Yadav, Kaya, Pant, & Tiwari, 2023). HCM in education involves aligning HR practices with educational objectives, emphasizing professional growth, and fostering collaboration among educators. The application of HCM principles to STEM education ensures that human resources are strategically deployed to maximize educational outcomes (Arokiasamy et al., 2023; Georgiev, 2020).

The Talent Management Framework is another compelling model. It focuses on identifying, developing, and retaining high-potential individuals in education, aligning closely with the specific needs of STEM fields (Lewis & Heckman, 2006; Oehley, 2007). Talent management in STEM education involves recognizing and nurturing educators' unique skills and expertise, creating a workforce that is technically proficient and equipped with the pedagogical skills required for effective STEM instruction (Council, 2011; Sublette, 2013). Partnerships between educational institutions and industry stakeholders exemplify collaborative models that integrate HR principles. These partnerships facilitate the exchange of knowledge and resources, ensuring that STEM education remains relevant and aligned with the workforce's needs. Industry collaboration also provides educators with real-world insights, enhancing their ability to prepare students for the demands of STEM careers (Boss & Krauss, 2022; Ehiyazaryan & Barraclough, 2009).

Although there has been progress in incorporating HR ideas into STEM education, significant gaps and obstacles remain. The shortage of skilled STEM educators is a major challenge. Retirements, attrition, and competition with industry for STEM professionals all contribute to the shortfall. To address this difficulty, focused recruitment tactics, competitive salary packages, and campaigns to entice persons with industrial expertise into teaching posts are required. Another major difficulty is professional development. To keep up with the latest advances in STEM subjects, instructors must engage in continual learning. Inadequate chances for continual training and upskilling might make it difficult for educators to integrate emerging technology and methodology into their teaching practices (Adelekea & Onyebuchib, 2023; L. Li, 2022; Markowitsch & Hefler, 2019; Tarling & Ng'ambi, 2016). To close this gap, strong professional development programs geared to the specific needs of STEM instructors must be established. Diversity and inclusion are also emerging as key issues in STEM education. The underrepresentation of specific demographic groups in STEM professions and education fosters a lack of diverse perspectives in the learning environment. Addressing these discrepancies necessitates concerted efforts in recruitment, support networks, and developing inclusive educational methods. Diversity enriches the learning environment and prepares students for the diverse and collaborative character of the STEM workforce.

2.4. Theoretical Framework

Establishing a solid theoretical framework is paramount in guiding the integration of HR principles into STEM education. Theoretical underpinnings provide a conceptual foundation, offering insights into the dynamics of human capital management, organizational behaviour, and educational psychology. A comprehensive theoretical framework helps to elucidate the relationships between HR practices and educational outcomes, laying the groundwork for strategic interventions and informed decision-making.

At the core of the theoretical framework lies the recognition that effective HR practices in STEM education are rooted in sound organizational and educational theories. One foundational theory is Human Capital Theory, which posits that investments in education and training contribute to accumulating skills and knowledge, enhancing an individual's human capital (Becker, 2009; Cornacchione & Daugherty, 2013). Applied to STEM education, this theory underscores the importance of strategic investment in developing and retaining skilled STEM educators, acknowledging their role as valuable assets in the educational system (Bowles & Gintis, 1975). Organizational Behavior Theories, such as the Expectancy Theory and the Social Exchange Theory, offer insights into the motivations and behaviours of individuals within an organizational context (Cook, Cheshire, Rice, & Nakagawa, 2013; Gould-Williams & Davies, 2005). Understanding educators' expectations, motivations, and social dynamics is crucial in STEM education. Expectancy Theory, for instance, suggests that individuals are motivated by the expectation that their efforts will lead to desired outcomes (Kanfer, 1990). Applying this theory to STEM educators involves aligning professional development opportunities and incentives with their expectations, fostering a sense of purpose and commitment.

Several HR theories provide valuable perspectives for integrating HR principles in STEM education (Krausert, 2017; Lynham, 2000). Strategic Human Resource Management (SHRM) theory emphasizes aligning HR practices with organizational goals. In the context of STEM education, this involves developing HR strategies closely tied to the overarching educational objectives, ensuring that STEM educators' recruitment, development, and retention contribute directly to improving STEM learning outcomes. The Resource-Based View (RBV) theory posits that resources (including human resources) can be a source of sustained competitive advantage (Clulow, Gerstman, & Barry, 2003; Madhani, 2010). Viewing educators as valuable resources in STEM education implies that strategic investments in their development and well-being can lead to a competitive advantage in delivering high-quality STEM education. This theory underscores the importance of HR practices in building and leveraging the educational capabilities of the workforce (Gaya & Struwig, 2016).

Building on these foundational theories, the conceptual framework for integrating HR principles in STEM education involves mapping out the relationships and interactions among key variables. The framework should consider the unique characteristics of STEM education, the needs of educators, and the desired educational outcomes (Kelley & Knowles, 2016; Murphy, MacDonald, & Danaia, 2020). Central to this conceptual framework is the understanding that HR practices are not isolated but interconnected elements that influence each other and contribute to the overall effectiveness of STEM education. Key components of the conceptual framework include recruitment strategies tailored to attract STEM professionals, professional development programs aligned with the dynamic nature of STEM fields, and retention initiatives addressing STEM educators' specific needs and expectations (Nadelson & Seifert, 2013; Stevens, Andrade, & Page, 2016). The framework should also incorporate mechanisms for assessing and adapting HR practices based on feedback, performance metrics, and evolving educational requirements.

Applying the theoretical framework to STEM education involves a nuanced understanding of this domain's unique challenges and opportunities. For instance, the framework should address the shortage of qualified STEM educators by incorporating targeted recruitment strategies, potentially leveraging industry partnerships to attract professionals with practical experience into teaching roles. Professional development initiatives should align with the fast-paced advancements in STEM fields, ensuring educators have the latest knowledge and pedagogical skills. Additionally, retention strategies should consider the factors that contribute to the job satisfaction of STEM educators, recognizing their need for autonomy, opportunities for research and collaboration, and a supportive work environment (Hall, 2023; McConnell, 2017; Suárez & Wright, 2019).

While the theoretical framework provides a solid foundation, subjecting it to critical analysis and adaptation is essential. Critiques may arise concerning the generalizability of certain HR theories to the educational context, potential oversights in addressing the diversity of STEM disciplines, or the dynamic nature of educational institutions. Adaptation involves refining the framework based on empirical evidence, ongoing research, and feedback from educators and administrators actively involved in STEM education. In conclusion, the theoretical framework is a compass for navigating the complex terrain of integrating HR principles into STEM education. It draws on established theories in HR and organizational behaviour. It adapts them to the specific needs and nuances of STEM education.

2.5. Integration Strategies

Successfully integrating HR principles into STEM education necessitates creative and purposeful approaches that address the particular problems and opportunities of science, technology, engineering, and mathematics. This section delves into essential integration tactics, such as STEM educator recruitment and retention, professional development programs, collaboration and team-building, and the promotion of diversity and inclusion.

2.6. Recruitment and Retention of STEM Educators

Designing targeted recruitment strategies is essential to address the persistent shortage of qualified STEM educators. Collaborative efforts between educational institutions and industries can help attract professionals with practical experience into teaching roles. Initiatives such as mentorship programs, outreach to industry conferences, and partnerships with STEM organizations can broaden the pool of potential educators. Recognizing the competitive nature of STEM fields, offering competitive compensation packages and incentives is crucial. This includes salary considerations and benefits such as opportunities for research, industry collaborations, and professional growth. Creating an environment that values and supports the professional development of STEM educators enhances their job satisfaction and retention. Acknowledging the dynamic nature of STEM professions and integrating workplace flexibility into educational settings can be powerful retention strategies (Honey, 2014; Margot & Kettler, 2019). This includes accommodating research pursuits, industry engagements, and flexible work arrangements catering to STEM educators' diverse needs and expectations.

2.7. Professional Development

Given the rapid evolution of STEM fields, providing continuous learning opportunities is integral. Establishing partnerships with industry leaders, hosting workshops, and offering online courses can ensure that STEM educators stay abreast of the latest advancements. Tailoring professional development programs to the specific needs of STEM disciplines, including emerging technologies and pedagogical innovations, enhances their effectiveness. Implementing mentorship programs connects experienced STEM educators with those entering the field, fostering knowledge exchange and community building. Mentorship contributes to the professional development of educators by providing guidance, sharing best practices, and creating a supportive network within the STEM education community. Recognizing and supporting educators' research pursuits enhances professional development and contributes to the integration of real-world applications into STEM education. Providing access to research grants, collaborative projects, and opportunities for publication strengthens the connection between academia and industry, enriching the educational experience for both educators and students (Dede, Eisenkraft, Frumin, & Hartley, 2016; X. Li & Li, 2023).

2.8. Collaboration and Team Building

Encouraging interdisciplinary collaboration among STEM educators facilitates the integration of multiple perspectives and approaches into STEM education. Collaborative projects, joint courses, and cross-disciplinary research initiatives foster a culture of teamwork and knowledge-sharing, enriching the learning experience for educators and students. Establishing partnerships with industry stakeholders is a powerful strategy to bridge the gap between education and the workforce. Industry partnerships provide insights into current industry needs, expose educators to practical applications of STEM concepts, and create pathways for students to transition seamlessly into STEM careers. Involving the local community in STEM education initiatives strengthens ties between educational institutions and their surroundings. Community engagement projects, outreach programs, and collaboration with local businesses enhance the visibility of STEM education and provide valuable resources and support (Khalil & Shea, 2012; Nurius & Kemp, 2019).

2.9. Diversity and Inclusion

Adopting diverse hiring practices ensures that STEM education benefits from various perspectives and experiences. Implementing blind recruitment processes, actively seeking candidates from underrepresented groups, and addressing unconscious biases contribute to a more inclusive and diverse teaching workforce. Promoting diversity and inclusion in STEM education extends beyond the hiring process. Incorporating diverse voices, cultures, and examples into curriculum design creates an inclusive learning environment. This approach reflects the diversity of the STEM workforce. It prepares students for the global and collaborative nature of STEM careers. Establishing support systems for educators from underrepresented groups is crucial. This includes mentorship programs, affinity groups, and resources to address specific challenges. Creating a sense of belonging and inclusivity is essential for the retention and success of educators from diverse backgrounds (Boyle et al., 2020; Griffin, Bennett, & York, 2020).

In conclusion, integration strategies in STEM education require a multifaceted approach that addresses recruitment, retention, professional development, collaboration, and diversity. By strategically implementing these strategies, educational institutions can create an environment that attracts and retains skilled STEM educators and prepares students for the challenges and opportunities of the dynamic STEM landscape. The integration of HR principles into these strategies ensures a holistic and effective approach to enhancing STEM education.

3. Implications and Recommendations

Integrating HR principles into STEM education has significant implications for educational institutions, policymakers, and the broader community. This section delves into the practical implications of aligning HR practices with STEM education goals. It provides recommendations for various stakeholders to enhance the effectiveness of STEM education.

3.1. Implications for Practice

Aligning HR practices with the strategic goals of STEM education involves comprehensive workforce planning. Educational institutions must proactively identify the current and future needs of STEM educators, considering the dynamic nature of STEM fields. This implies continuous collaboration between HR departments, academic leadership, and industry partners to anticipate demand and adjust recruitment and development strategies accordingly.

The integration of HR principles underscores the importance of continuous professional development for STEM educators. Educational institutions should invest in robust professional development programs that address the technical aspects of STEM and focus on pedagogical innovation, collaborative skills, and the ability to adapt to emerging trends (Manduca et al., 2017; Shernoff, Sinha, Bressler, & Ginsburg, 2017). This investment not only benefits educators but has a direct impact on the quality of STEM education delivered to students. A positive and inclusive organizational culture is vital for attracting and retaining STEM educators. Institutions should foster an environment that values diversity, encourages collaboration, and supports a healthy work-life balance. Recognizing and celebrating the contributions of educators, providing mentorship opportunities, and creating avenues for constructive feedback contribute to a positive culture that enhances job satisfaction and overall well-being.

3.2. Recommendations for Policymakers

Policymakers can play a crucial role in incentivizing STEM education careers. This involves creating policies that provide competitive compensation, benefits, and incentives for STEM educators. Financial support for professional development, research endeavours, and recognition programs can further enhance the attractiveness of teaching in STEM fields. Facilitating public-private partnerships is essential for bridging the gap between education and industry. Policymakers should encourage collaborations between educational institutions and STEM industries, creating pathways for educators to engage in real-world projects, internships, and industry training. Such partnerships benefit educators and ensure that STEM education remains relevant to industry needs. Policymakers should prioritize inclusive education policies that promote diversity in STEM education. This includes initiatives to increase representation from underrepresented groups, address systemic barriers, and foster an inclusive curriculum. By implementing policies that support diverse hiring practices and create an inclusive learning environment, policymakers contribute to a more equitable STEM education landscape.

3.3. Recommendations for Researchers

Researchers can contribute by conducting longitudinal studies to assess the long-term impact of integrating HR practices into STEM education. Examining the effectiveness of recruitment strategies, the outcomes of professional development initiatives, and the retention rates of STEM educators over time can provide valuable insights into the sustainability of HR integration. Research should focus on evaluating the effectiveness of diversity and inclusion initiatives in STEM education. Understanding the impact of inclusive curriculum design, mentorship programs, and support systems for underrepresented groups can guide future interventions and contribute to creating more inclusive STEM learning environments. Comparative studies across different educational systems can offer insights into the transferability of HR integration strategies. Researchers can explore how HR practices tailored to local contexts impact STEM education outcomes, considering cultural, economic, and educational system differences. Comparative studies contribute to developing adaptable models that can be customized for diverse settings.

The integration of HR principles into STEM education has far-reaching implications for the overall advancement of the field. By aligning human capital management with educational objectives, institutions contribute to creating a skilled and adaptable STEM workforce. This, in turn, enhances national competitiveness, fosters innovation, and prepares individuals for the challenges of a technology-driven future. Additionally, the emphasis on diversity and inclusion in

STEM education has societal implications. A more inclusive and diverse STEM workforce addresses equity concerns. It contributes to a broader range of perspectives, ideas, and innovations. In the long run, this benefits not only educational institutions and the workforce but society as a whole.

4. Conclusion

In conclusion, integrating HR principles into STEM education is a transformative endeavor with profound implications for educational institutions, policymakers, and the broader community. The theoretical framework, spanning Human Capital Theory, Organizational Behavior Theories, and Strategic Human Resource Management, provides a solid foundation for understanding the dynamics between HR practices and the goals of STEM education. This theoretical grounding facilitates a nuanced exploration of integration strategies, addressing key facets such as recruitment, professional development, collaboration, and diversity.

The recommended strategies outlined in this review offer actionable insights for practitioners, policymakers, and researchers alike. For educational institutions, strategic workforce planning, investment in professional development, and the cultivation of a positive organizational culture emerge as imperative practices. Policymakers are encouraged to incentivize STEM education careers, foster public-private partnerships, and advocate for inclusive education policies. Researchers are called upon to conduct longitudinal studies, evaluate diversity initiatives, and engage in comparative analyses across educational systems to refine and enhance integration models continually.

Overall, the contributions of this review extend beyond the immediate considerations of HR integration. They encompass the broader goals of fostering a skilled, diverse, and adaptable STEM workforce capable of addressing the challenges and opportunities of the 21st century. As we navigate the complexities of the evolving STEM landscape, the integration of HR principles emerges not merely as an administrative necessity but as a fundamental reimagining of how we cultivate, support, and empower the educators shaping the next generation of STEM professionals. When thoughtfully implemented, this integration has the potential to propel STEM education into a realm of excellence that aligns seamlessly with the needs of the workforce and the aspirations of individuals pursuing careers in science, technology, engineering, and mathematics.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Aboramadan, M., Albashiti, B., Alharazin, H., & Dahleez, K. A. (2020). Human resources management practices and organizational commitment in higher education: The mediating role of work engagement. *International Journal of Educational Management, 34*(1), 154-174.

[2] Adelekea, I. J., & Onyebuchib, C. N. (2023). CHALLENGES TEACHERS EXPERIENCE IN TEACHING ENGLISH SECOND LANGUAGE IN SECONDARY SCHOOLS IN THE NORTHWEST PROVINCE.

[3] Agarwala, T. (2007). Strategic human resource management.

[4] Aldemir, J., & Kermani, H. (2017). Integrated STEM curriculum: improving educational outcomes for Head Start children. *Early Child Development and Care, 187*(11), 1694-1706.

[5] Allui, A., & Sahni, J. (2016). Strategic human resource management in higher education institutions: empirical evidence from Saudi. *Procedia-Social and Behavioral Sciences, 235*, 361-371.

[6] Arokiasamy, L., Fujikawa, T., Piaralal, S. K., & Arumugam, T. (2023). A systematic review of literature on Human capital investment and its significance for human resource development. *International Journal of System Assurance Engineering and Management, 14*(5), 1810-1826.

[7] Baran, E., BİLİCİ, S., Mesutoglu, C., & Ocak, C. (2016). Moving STEM beyond schools: Students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics Science and Technology, 4*(1).

[8] Becker, G. S. (2009). *Human capital: A theoretical and empirical analysis, with special reference to education*: University of Chicago press.

[9] Boss, S., & Krauss, J. (2022). *Reinventing project-based learning: Your field guide to real-world projects in the digital age*: International Society for Technology in Education.

[10] Bowles, S., & Gintis, H. (1975). The problem with human capital theory--a Marxian critique. *The American Economic Review, 65*(2), 74-82.

[11] Boyle, S. R., Pearson, Y. E., Phillips, C. M., Mattingly, S. P., DesRoches, R., Li, W., . . . Sharma, P. (2020). *An exploratory study of intentionality toward diversity in STEM faculty hiring.* Paper presented at the American Society of Engineering Education.

[12] Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities.

[13] Clulow, V., Gerstman, J., & Barry, C. (2003). The resource-based view and sustainable competitive advantage: the case of a financial services firm. *Journal of European Industrial Training, 27*(5), 220-232.

[14] Cook, K. S., Cheshire, C., Rice, E. R., & Nakagawa, S. (2013). Social exchange theory. *Handbook of social psychology*, 61-88.

[15] Cornacchione, E., & Daugherty, J. L. (2013). Trends in opportunity costs of US postsecondary education: A national HRD and human capital theory analysis. *New Horizons in Adult Education and Human Resource Development, 25*(2), 62-82.

[16] Council, N. R. (2011). *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics*: National Academies Press.

[17] Dede, C., Eisenkraft, A., Frumin, K., & Hartley, A. (2016). *Teacher learning in the digital age: Online professional development in STEM education*: Harvard Education Press.

[18] Ehiyazaryan, E., & Barraclough, N. (2009). Enhancing employability: integrating real world experience in the curriculum. *Education+ Training, 51*(4), 292-308.

[19] Ewim, D. R. E. (2023). Integrating Business Principles in STEM Education: Fostering Entrepreneurship in Students and Educators in the US and Nigeria. *IJEBD (International Journal of Entrepreneurship and Business Development), 6*(4), 590-605.

[20] Gaya, H., & Struwig, M. (2016). Is Activity-Resource-Based View (ARBV) the new theory of the firm for creating sources of sustainable competitive advantage in services firms. *Global Journal of Management and Business Research: An Administration and Management, 16*(5), 32-45.

[21] Georgiev, G. S. (2020). The Human Capital Management Movement in US Corporate Law. *Tul. L. Rev., 95*, 639.

[22] Gould-Williams, J., & Davies, F. (2005). Using social exchange theory to predict the effects of HRM practice on employee outcomes: An analysis of public sector workers. *Public management review, 7*(1), 1-24.

[23] Griffin, K., Bennett, J., & York, T. (2020). Leveraging promising practices: Improving the recruitment, hiring, and retention of diverse & inclusive faculty.

[24] Hall, C. J. (2023). *The STEM Teacher Shortage: A Case Study Exploring Arizona Teachers' Job Satisfaction and Retention Intention.* Northcentral University,

[25] Honey, M. (2014). Committee on Integrated STEM Education Margaret Honey, Greg Pearson, and Heidi Schweingruber, Editors.

[26] Kanfer, R. (1990). Motivation theory and industrial and organizational psychology. *Handbook of industrial and organizational psychology, 1*(2), 75-130.

[27] Kazlauskaitė, R., & Bučiūnienė, I. (2008). The role of human resources and their management in the establishment of sustainable competitive advantage. *Inžinerinė ekonomika*(5), 78-84.

[28] Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*, 1-11.

[29] Khalil, O. E., & Shea, T. (2012). Knowledge sharing barriers and effectiveness at a higher education institution. *International Journal of Knowledge Management (IJKM), 8*(2), 43-64.

[30] Krausert, A. (2017). HR differentiation between professional and managerial employees: Broadening and integrating theoretical perspectives. *Human Resource Management Review, 27*(3), 442-457.

[31] Lewis, R. E., & Heckman, R. J. (2006). Talent management: A critical review. *Human Resource Management Review, 16*(2), 139-154.

[32] Li, L. (2022). Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. *Information Systems Frontiers*, 1-16.

[33] Li, X., & Li, Y. (2023). Individualized and innovation-centered general education in a Chinese STEM University. *Education Sciences, 13*(8), 846.

[34] Lo, C. K. (2021). Design principles for effective teacher professional development in integrated STEM education. *Educational Technology & Society, 24*(4), 136-152.

[35] Lynham, S. A. (2000). Theory building in the human resource development profession. *Human Resource Development Quarterly, 11*(2), 159-178.

[36] Madhani, P. M. (2010). Resource based view (RBV) of competitive advantage: an overview. *Resource based view: concepts and practices, Pankaj Madhani, ed*, 3-22.

[37] Manduca, C. A., Iverson, E. R., Luxenberg, M., Macdonald, R. H., McConnell, D. A., Mogk, D. W., & Tewksbury, B. J. (2017). Improving undergraduate STEM education: The efficacy of discipline-based professional development. *Science Advances, 3*(2), e1600193.

[38] Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education, 6*(1), 1-16.

[39] Markowitsch, J., & Hefler, G. (2019). *Future developments in Vocational Education and Training in Europe: Report on reskilling and upskilling through formal and vocational education training*. Retrieved from

[40] McConnell, J. R. (2017). A model for understanding teachers' intentions to remain in STEM education. *International Journal of STEM Education, 4*, 1-21.

[41] Murphy, S., MacDonald, A., & Danaia, L. (2020). Sustaining STEM: A framework for effective STEM education across the learning continuum. *STEM education across the learning continuum: Early childhood to senior secondary*, 9-28.

[42] Nadelson, L. S., & Seifert, A. (2013). Perceptions, engagement, and practices of teachers seeking professional development in place-based integrated STEM. *Teacher Education and Practice, 26*(2), 242-266.

[43] Nurius, P. S., & Kemp, S. P. (2019). Individual-level competencies for team collaboration with cross-disciplinary researchers and stakeholders. *Strategies for team science success: Handbook of evidence-based principles for cross-disciplinary science and practical lessons learned from health researchers*, 171-187.

[44] Oehley, A.-M. (2007). *The development and evaluation of a partial talent management competency model.* Stellenbosch: University of Stellenbosch,

[45] Olanike S, A., Asogwa, C. N., Njideka M, O., RE, E. D., & Temiloluwa O, S. (2023). A Comparison of Perceptions of Assessment Practices in Higher Institutions between Academic Staff and Students: A Case Study of Federal College of Education, Yola. *International Journal of Social Sciences & Educational Studies, 10*(3).

[46] Rafiei, N., & Davari, F. (2015). The role of human resources management on enhancing the teaching skills of faculty members. *Materia socio-medica, 27*(1), 35.

[47] Ramirez, F. O., Kwak, N., Seely-Gant, K., Ogawa, M., Frehill, L. M., Atwaters, S. Y., . . . Akimana, R. (2015). Women's enrollments in STEM in higher education: Cross-national trends, 1970–2010. In *Advancing women in science: An international perspective* (pp. 9-49): Springer.

[48] Sharma, J., & Yarlagadda, P. K. (2018). Perspectives of 'STEM education and policies' for the development of a skilled workforce in Australia and India. *International Journal of Science Education, 40*(16), 1999-2022.

[49] Shen, J., Chanda, A., D'netto, B., & Monga, M. (2009). Managing diversity through human resource management: An international perspective and conceptual framework. *The International Journal of Human Resource Management, 20*(2), 235-251.

[50] Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education. *International Journal of STEM Education, 4*, 1-16.

[51] Shore, L. M., Cleveland, J. N., & Sanchez, D. (2018). Inclusive workplaces: A review and model. *Human Resource Management Review, 28*(2), 176-189.

[52] Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student attraction, persistence and retention in STEM programs: Successes and continuing challenges. *Higher Education Studies, 7*(1), 46-59.

[53] Sriratanaviriyakul, N., & El-Den, J. (2017). Motivational factors for knowledge sharing using pedagogical discussion cases: students, educators, and environmental factors. *Procedia Computer Science, 124*, 287-299.

[54] Stevens, S., Andrade, R., & Page, M. (2016). Motivating young Native American students to pursue STEM learning through a culturally relevant science program. *Journal of Science Education and Technology, 25*, 947-960.

[55] Suárez, M. I., & Wright, K. B. (2019). Investigating school climate and school leadership factors that impact secondary STEM teacher retention. *Journal for STEM Education Research, 2*, 55-74.

[56] Sublette, H. (2013). *An effective model of developing teacher leaders in STEM education.* Pepperdine University,

[57] Sumarni, W., Sudarmin, S., Sumarti, S. S., & Kadarwati, S. (2022). Indigenous knowledge of Indonesian traditional medicines in science teaching and learning using a science–technology–engineering–mathematics (STEM) approach. *Cultural Studies of Science Education*, 1-44.

[58] Tan, C. N.-L. (2016). Enhancing knowledge sharing and research collaboration among academics: the role of knowledge management. *Higher education, 71*, 525-556.

[59] Tarling, I., & Ng'ambi, D. (2016). Teachers pedagogical change framework: a diagnostic tool for changing teachers' uses of emerging technologies. *British Journal of Educational Technology, 47*(3), 554-572.

[60] Tytler, R., Osborne, J., Williams, G., Tytler, K., & Cripps Clark, J. (2008). Opening up pathways: Engagement in STEM across the primary-secondary school transition. *Canberra: Australian Department of Education, Employment and Workplace Relations*.

[61] Wang, L.-H., Chen, B., Hwang, G.-J., Guan, J.-Q., & Wang, Y.-Q. (2022). Effects of digital game-based STEM education on students' learning achievement: a meta-analysis. *International Journal of STEM Education, 9*(1), 1-13.

[62] Yadav, R. S., Kaya, S. K., Pant, A., & Tiwari, A. (2023). AI-enabled human capital management (HCM) software adoption using full consistency method (FUCOM): evidence from banking industry. *Global Knowledge, Memory and Communication*.