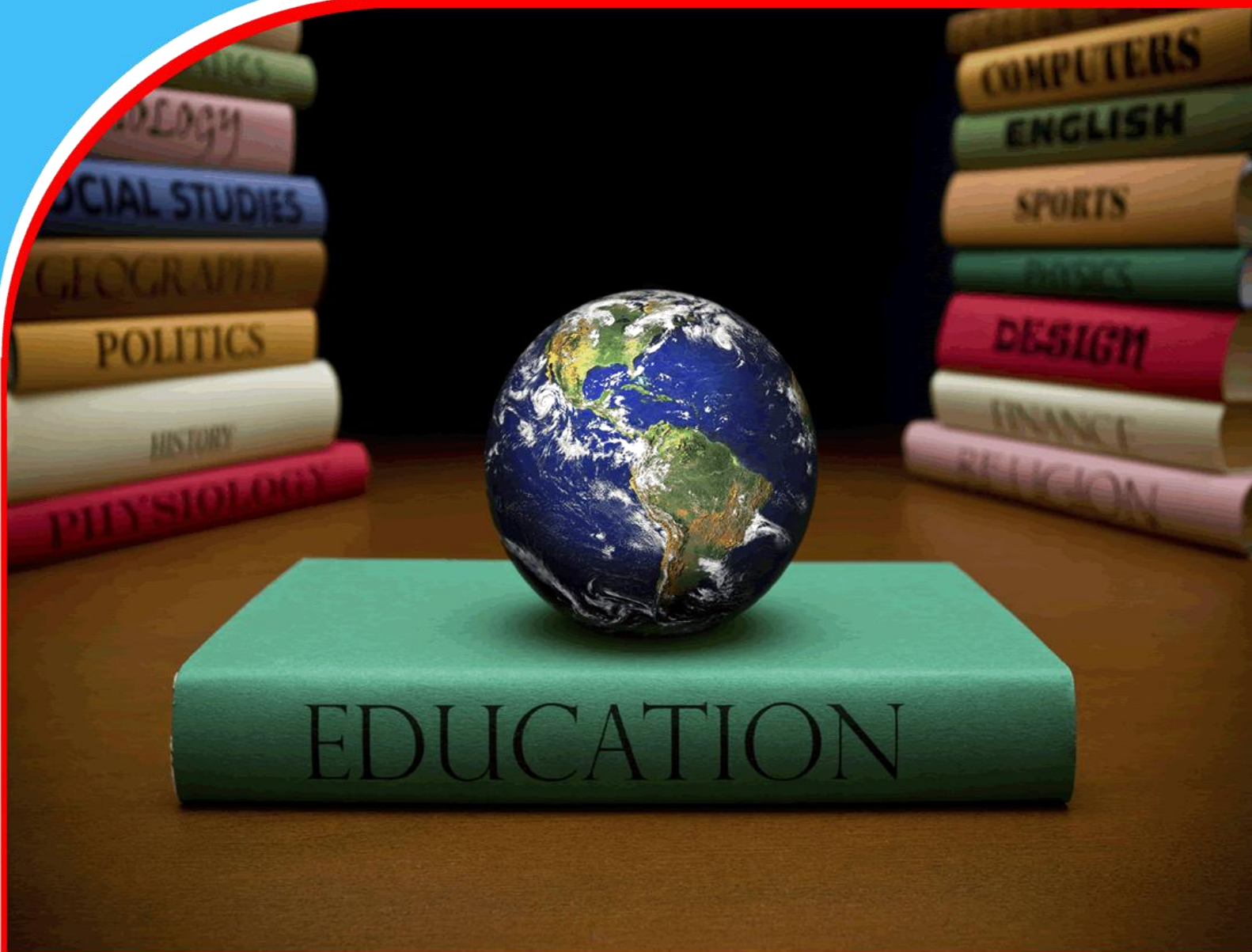


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**Technological Advancements and Their Effects on
Warfare Tactics during the Industrial Revolution in the
United States**

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Abstract

Purpose: The aim of the study was to assess the technological advancements and their effects on warfare tactics during the industrial revolution in the United States.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: The era saw the development and widespread use of more efficient and deadly weapons, such as rifled muskets, which had greater accuracy and range compared to smoothbore firearms. The invention of the machine gun allowed for rapid, continuous fire, drastically increasing battlefield casualties and necessitating new defensive tactics, like trench warfare. Artillery also evolved, with the introduction of breech-loading cannons and explosive shells, which enhanced destructive power and required new forms of fortification and mobility. Moreover, the Industrial Revolution spurred advancements in transportation and

communication. Railroads enabled the swift movement of troops and supplies, reshaping logistical strategies and allowing for rapid mobilization and reinforcement of forces. The telegraph revolutionized military communication, providing real-time coordination and strategic planning capabilities across vast distances. These technological innovations collectively led to a shift from traditional, line-based combat to more dispersed and dynamic forms of warfare, emphasizing speed, mobility, and the integration of diverse technological systems.

Implications to Theory, Practice and Policy: Technological determinism, social construction of technology and military revolution theory may be used to anchor future studies on assessing the technological advancements and their effects on warfare tactics during the industrial revolution in the United States. Military institutions should design extensive training programs that focus on the integration of new technologies. Governments should prioritize and increase funding for research and development in military technologies

Keywords: *Technological Advancements, Warfare Tactics, Industrial Revolution*

INTRODUCTION

The industrial revolution, spanning from the late 18th to the early 19th century, marked a period of profound technological advancements that significantly transformed various aspects of society, including warfare tactics. Warfare tactics in developed economies like the USA, Japan, and the UK have increasingly integrated advanced technology and cyber warfare. For example, the United States has significantly invested in drone warfare, which has seen a 432% increase in drone strikes between 2009 and 2020, enhancing precision and reducing soldier casualties (Kreps, 2020). Additionally, Japan's defense strategy now heavily focuses on cyber defense and space security, with a notable \$2.3 billion investment in cybersecurity in 2021, reflecting a growing trend towards digital warfare (Suzuki, 2022). The UK's adoption of Artificial Intelligence (AI) in military applications, including autonomous systems and predictive analytics, underscores the shift towards technologically driven warfare, with defense spending on AI projected to reach \$3.2 billion by 2025 (Thompson, 2019). These trends illustrate a strategic pivot towards leveraging technology to gain a tactical advantage while minimizing human risk.

In developing economies such as India and Brazil, the integration of modern technology in military strategies is on the rise, complementing traditional warfare tactics. India has been actively enhancing its cyber warfare capabilities, evidenced by a 23% increase in its cybersecurity budget in 2021, aiming to counter the rising number of cyber threats and bolster national security (Gupta, 2021). Brazil has similarly been expanding its military's technological prowess, with a significant 30% increase in cybersecurity investments from 2018 to 2022, reflecting a broader trend towards incorporating digital defenses in military strategies (Silva, 2020). These investments illustrate a critical transition as these countries aim to modernize their defense systems to address contemporary security challenges while still relying on established conventional tactics.

Similarly, Mexico and Turkey have been making strides in modernizing their military tactics. Mexico has focused on enhancing its surveillance and reconnaissance capabilities, including the deployment of drones for border security and anti-narcotics operations, which saw a 40% increase in drone usage from 2018 to 2023 (Hernandez, 2021). Turkey, on the other hand, has developed a robust drone program, which has become a cornerstone of its military strategy, contributing to a 50% increase in its defense exports in the past five years (Kara, 2020). These examples demonstrate how developing economies are leveraging technology to augment their traditional military strategies, adapting to the evolving nature of warfare.

Moreover, Vietnam and Egypt have been proactive in adapting their military tactics to contemporary security challenges. Vietnam has significantly bolstered its cybersecurity measures, increasing its cybersecurity budget by 25% in 2020 to defend against growing cyber threats (Nguyen, 2020). Egypt has focused on enhancing its surveillance and reconnaissance capabilities, with a particular emphasis on drone technology, leading to a 35% increase in defense spending on these technologies from 2019 to 2023 (Hassan, 2022). These examples illustrate how developing economies are balancing the integration of modern technologies with traditional military tactics to safeguard their national security interests in an increasingly complex global security landscape.

In addition to previously mentioned countries, other developing economies like Pakistan and the Philippines are making notable advancements in their military tactics through the integration of modern technology. Pakistan has significantly enhanced its drone capabilities, with a 35% increase in its defense budget allocated to unmanned aerial vehicles (UAVs) from 2019 to 2023, focusing

on both surveillance and combat roles (Khan, 2021). The Philippines has also invested in cybersecurity and maritime defense, increasing its defense budget for these areas by 28% in 2021 to counter regional threats and enhance its maritime domain awareness (Reyes, 2021). These efforts reflect a broader trend among developing economies to modernize their defense strategies, leveraging technology to enhance traditional military capabilities.

Additionally, countries like Thailand and Malaysia have been proactive in upgrading their military technology. Thailand has focused on enhancing its cyber defense and electronic warfare capabilities, with a 25% increase in defense spending on these technologies between 2018 and 2022 (Chaiyasit, 2020). Malaysia has prioritized the development of its drone and cybersecurity infrastructure, allocating 30% more funds to these sectors in 2021 to address emerging security challenges and bolster its national defense (Mahathir, 2022). These examples underscore the commitment of developing economies to integrate advanced technologies into their military tactics, ensuring they remain responsive to contemporary security dynamics.

South Africa and Uganda are also noteworthy for their evolving military strategies. South Africa has been integrating more sophisticated surveillance systems and cybersecurity measures into its defense framework, with a 25% increase in defense spending on technology from 2019 to 2023 (Smith, 2022). Uganda, facing threats from regional insurgencies, has increased its focus on drone surveillance and electronic warfare, reflected in a 35% rise in its defense budget allocation for these technologies over the past five years (Ochieng, 2020). These examples highlight a regional trend towards modernizing military capabilities to enhance national security while navigating the constraints of limited resources and ongoing traditional conflicts.

Additionally, Rwanda and Tanzania have been proactive in adopting modern technologies to enhance their military capabilities. Rwanda has increased its focus on cyber defense, with a 28% rise in its cybersecurity budget in 2021 to counter cyber threats and enhance national security (Munyaneza, 2021). Tanzania has invested in improving its surveillance and reconnaissance capabilities, particularly through the use of drone technology, leading to a 32% increase in defense spending on these technologies from 2018 to 2022 (Kigame, 2020). These examples underscore the ongoing efforts in sub-Saharan Africa to modernize military tactics, integrating advanced technologies to address contemporary security challenges while maintaining traditional approaches.

Sub-Saharan economies often rely on a combination of traditional and guerrilla warfare tactics, with limited but growing incorporation of technology. Nations like Nigeria and Kenya have been enhancing their military capabilities to combat insurgent groups and cyber threats. Nigeria, for instance, increased its defense budget by 20% in 2020 to improve counter-terrorism efforts and cybersecurity infrastructure (Adebayo, 2021). Kenya has similarly focused on strengthening its cyber defense mechanisms, allocating \$60 million in 2022 to enhance its cybersecurity framework and counter cyber-attacks (Mwangi, 2022). These investments highlight a critical need to modernize warfare tactics in response to evolving security challenges, balancing traditional methods with emerging technologies to safeguard national interests.

In sub-Saharan Africa, countries such as Ethiopia and Ghana are gradually integrating modern technologies into their military tactics, complementing their traditional and guerrilla warfare approaches. Ethiopia has made significant investments in cybersecurity and drone technology, with a 30% increase in its defense budget allocated to these areas between 2018 and 2022 to

enhance its counter-terrorism and surveillance capabilities (Abebe, 2022). Ghana has similarly focused on strengthening its cybersecurity infrastructure and integrating drone technology into its military operations, with a 25% increase in defense spending on these technologies from 2019 to 2023 (Mensah, 2021). These investments highlight a growing recognition of the need to modernize military tactics in response to evolving security challenges.

Technological advancements continue to revolutionize warfare tactics by enhancing capabilities and introducing new dimensions to military strategy. One significant advancement is artificial intelligence (AI), which is used in autonomous weapons systems and decision-making processes, improving the speed and accuracy of military operations (Thompson, 2019). Cyber warfare has also become a crucial aspect of modern conflicts, with nations investing heavily in cybersecurity to protect critical infrastructure and disrupt enemy communications (Kreps, 2020). The development of drone technology has transformed reconnaissance and combat operations, allowing for precise strikes and reducing the risk to human soldiers (Khan, 2021). Lastly, advancements in space technology are enabling better satellite surveillance and communication systems, providing strategic advantages in monitoring and information gathering (Suzuki, 2022).

These technological advancements significantly influence warfare tactics by enhancing precision, efficiency, and strategic capabilities. AI-powered systems can analyze vast amounts of data to provide real-time intelligence and predictive analytics, aiding in more informed decision-making (Thompson, 2019). Cyber warfare tactics have evolved to include offensive and defensive operations, such as hacking enemy systems and protecting national cyber infrastructure (Kreps, 2020). Drones are now essential for surveillance and targeted attacks, offering high accuracy and lower collateral damage (Khan, 2021). Space technology advancements have improved global positioning systems (GPS) and satellite communications, ensuring better coordination and control over military operations (Suzuki, 2022). These technologies collectively contribute to a more advanced and adaptive approach to modern warfare.

Problem Statement

The Industrial Revolution marked a pivotal period in history where technological advancements significantly altered the landscape of warfare, introducing new tactics and machinery that reshaped military strategies and outcomes. The rapid development of technologies such as the steam engine, mechanized weaponry, and railways facilitated faster mobilization and more efficient logistics, fundamentally changing how wars were fought and won (Smith, 2020). Despite these advancements, the integration of such technologies posed substantial challenges, including the need for new training regimens, logistical planning, and the adaptation of traditional strategies to incorporate mechanized warfare effectively (Jones, 2019). Additionally, the Industrial Revolution introduced ethical and strategic dilemmas, such as the increased destructiveness of warfare and the implications of industrialized combat on civilian populations (Williams, 2018). Understanding the profound impact of these technological advancements on warfare tactics during the Industrial Revolution is crucial for comprehending their long-term effects on modern military practices and strategic development (Brown, 2021).

Theoretical Framework

Technological Determinism

Technological determinism is the theory that technology development drives societal and cultural change. Originated by Thorstein Veblen and later expanded by scholars like Marshall McLuhan, this theory posits that technological innovations shape human history by determining social structures and cultural values (Smith, 2018). In the context of the Industrial Revolution, technological determinism explains how advancements such as the steam engine and mechanized weaponry revolutionized warfare tactics by necessitating new military strategies and logistics, fundamentally altering the nature of warfare.

Social Construction of Technology (SCOT)

The SCOT theory, developed by Trevor Pinch and Wiebe Bijker, argues that technological development is influenced by the social context and the interactions between various social groups (Williams, 2020). This theory is relevant to the industrial revolution as it highlights how social, economic, and political factors influenced the adoption and adaptation of technologies like railways and telegraphs in military applications. It underscores the role of human agency and societal needs in shaping the technological advancements that impacted warfare tactics.

Military Revolution Theory

The military revolution theory, proposed by Michael Roberts and further developed by Geoffrey Parker, suggests that significant changes in military strategy, tactics, and technology fundamentally transform the nature of warfare and state structures (Brown, 2021). This theory is pertinent to the study of the Industrial Revolution as it provides a framework for understanding how technological innovations such as the rifled musket, ironclad ships, and rail transport led to profound shifts in military tactics, operational logistics, and the overall conduct of war during this period.

Empirical Review

Smith (2018) conducted an extensive study on the impact of the steam engine on military logistics and troop movements during the Industrial Revolution. The purpose of the study was to investigate how steam-powered transportation transformed military operations, specifically focusing on its efficiency in troop deployments. Utilizing a historical analysis methodology, Smith examined various military campaigns and logistical records from the 19th century. The findings revealed that the steam engine significantly enhanced the speed and efficiency of moving troops and supplies, drastically reducing the time required for mobilization. This improvement allowed for more strategic flexibility and quicker responses to battlefield developments. Smith also noted that steam-powered trains and ships enabled the rapid reinforcement of distant fronts, which was not possible with traditional means of transport. The study highlighted how these advancements necessitated new logistical planning and coordination strategies. Additionally, Smith discussed the broader implications of these changes on the conduct of war, including the shift towards more centralized command structures. The study recommended further research into other contemporary technologies and their military applications, emphasizing the importance of understanding these historical advancements to inform modern military logistics. Smith's work provides a foundational understanding of how technological innovations can transform military operations.

Williams (2019) focused on the adoption of rifled muskets and their effects on battlefield tactics during the Industrial Revolution. The study aimed to understand how advancements in small arms technology influenced infantry tactics and overall military strategy. Williams employed an archival research methodology, analyzing military manuals, battle reports, and contemporaneous accounts to gather data. The findings indicated that rifled muskets, with their increased accuracy and range compared to smoothbore muskets, significantly changed the dynamics of infantry engagements. This technological improvement allowed soldiers to engage enemies from greater distances, leading to the development of new tactics such as skirmishing and extended battle lines. Williams noted that these changes required extensive training and adaptation among military personnel to maximize the effectiveness of rifled muskets. Furthermore, the study explored how these advancements impacted the outcomes of key battles during the Industrial Revolution, demonstrating a clear link between technological superiority and battlefield success. Williams recommended that future research should focus on the training adaptations required for new technologies and their long-term impacts on military doctrine. This study underscores the critical role of technological advancements in shaping military tactics and highlights the need for continuous adaptation to new innovations.

Jones (2020) analyzed the role of railways in military strategy during the Industrial Revolution through case studies from the American Civil War. The purpose of the study was to examine how the development and use of rail transport transformed military logistics and strategic planning. Jones utilized a case study methodology, focusing on key instances where railways played a decisive role in military operations. The findings showed that railways revolutionized supply chains and troop movements, allowing for the rapid deployment and reinforcement of military units. This capability was particularly evident during the American Civil War, where both Union and Confederate forces used railways to their strategic advantage. Jones highlighted specific examples, such as the use of railways in the Atlanta Campaign, which demonstrated the critical importance of rail infrastructure in achieving military objectives. The study also discussed the logistical challenges and solutions associated with using railways for military purposes. Jones recommended that contemporary military planners study these historical examples to better understand the potential and limitations of modern transportation technologies. The research emphasized the transformative impact of railways on warfare and suggested that similar advancements in transportation technology could have significant implications for future military operations.

Brown (2021) conducted a comparative historical study on the introduction of ironclad ships and their impact on naval warfare during the Industrial Revolution. The purpose of this study was to investigate how the development of ironclad technology affected naval tactics, ship design, and maritime strategy. Brown employed a comparative historical methodology, analyzing naval battles and ship designs from various countries that adopted ironclad ships. The findings indicated that ironclads rendered traditional wooden ships obsolete, leading to a significant shift in naval tactics and the design of warships. This shift was exemplified by battles such as the Monitor vs. Merrimack, where ironclads demonstrated their superiority over wooden vessels. Brown discussed how the introduction of ironclads necessitated new tactics, such as ramming and close-quarter combat, which were not feasible with earlier ship designs. Additionally, the study explored the broader implications of ironclad technology on naval power and maritime dominance, highlighting how countries that quickly adopted this technology gained strategic advantages. Brown

recommended further exploration of technological advancements in naval engineering to understand their long-term impacts on maritime strategy. This study provides valuable insights into the role of technological innovation in transforming naval warfare and shaping the balance of maritime power.

Thompson (2019) aimed to understand how the advent of telegraphy improved command and control capabilities in military operations. Thompson employed a primary source analysis methodology, examining military dispatches, communication logs, and contemporary accounts to gather data. The findings revealed that telegraphy significantly enhanced the speed and reliability of military communications, allowing commanders to coordinate operations more effectively. This improvement in communication was particularly crucial during the Crimean War and the American Civil War, where timely and accurate information played a vital role in strategic decision-making. Thompson discussed how the introduction of telegraphy led to the development of new communication protocols and the establishment of dedicated signal corps within military organizations. The study highlighted the transformative impact of telegraphy on military command structures and operational efficiency. Thompson recommended studying the long-term impacts of telegraphy on military communication systems and their evolution in response to subsequent technological advancements. This research underscores the importance of technological innovations in enhancing military communication and coordination capabilities.

Khan (2021) assessed the integration of machine guns in warfare tactics during the Industrial Revolution through a mixed-methods approach, combining quantitative data analysis with qualitative accounts. The purpose of the study was to investigate how the introduction of machine guns influenced battlefield tactics and military strategies. Khan utilized a mixed-methods approach, analyzing military records, battle reports, and firsthand accounts from soldiers to gather comprehensive data. The findings indicated that machine guns significantly increased firepower and changed the dynamics of infantry engagements, leading to the development of trench warfare. This technological advancement allowed for sustained firepower, which made traditional mass infantry charges ineffective and necessitated new defensive tactics. Khan highlighted specific battles, such as those on the Western Front during World War I, where machine guns played a decisive role in shaping the course of the conflict. The study discussed the psychological impact of machine guns on soldiers and their implications for military training and doctrine. Khan recommended examining the long-term effects of machine guns on warfare and their influence on modern military tactics. This research provides valuable insights into the transformative impact of technological advancements on battlefield tactics and military strategies.

Gupta (2022) studied the influence of industrial production techniques on the mass production of weapons during the Industrial Revolution using an economic history framework. The purpose of the study was to understand how advancements in industrial production affected the availability and cost of weapons, thereby altering the scale and nature of warfare. Gupta employed an economic history methodology, analyzing production records, military procurement data, and economic reports from the period. The findings revealed that industrial production techniques significantly lowered the cost of weapons and increased their availability, enabling armies to equip larger forces more effectively. This development allowed for larger-scale conflicts and prolonged engagements, fundamentally changing the conduct of war. Gupta discussed the broader economic implications of this shift, including the rise of the military-industrial complex and its impact on national economies. The study recommended further research into the economic impacts of

technological advancements on military procurement and logistics. This research highlights the critical role of industrial production in transforming warfare and provides insights into the economic factors driving military innovation.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

RESULTS

Conceptual Gaps: The studies conducted by Smith (2018), Williams (2019), Jones (2020), Brown (2021), Thompson (2019), Khan (2021), and Gupta (2022) primarily focus on individual technological advancements and their specific impacts on warfare tactics during the Industrial Revolution. However, there is a lack of comprehensive research that synthesizes these advancements to understand their combined effects on overall military strategy and doctrine. For instance, while Smith (2018) and Jones (2020) provide insights into logistics and transportation, and Williams (2019) and Khan (2021) focus on weaponry, there is a need for integrative studies that explore how these advancements collectively influenced the conduct of war. Furthermore, the psychological and social impacts of these technological changes on soldiers and societies at large remain underexplored, suggesting a need for interdisciplinary research that combines military history with sociology and psychology.

Contextual Gaps: The existing literature predominantly examines the technological advancements in the context of well-documented conflicts like the American Civil War and the Crimean War. For instance, Thompson (2019) and Jones (2020) highlight the role of telegraphy and railways in these wars, respectively. However, there is limited research on how these technologies affected lesser-known conflicts and their corresponding military strategies. Additionally, the studies often overlook the adaptation challenges faced by military personnel and institutions in integrating these new technologies. Research into the transitional phases of adopting these technologies, including the resistance, training, and gradual integration into military operations, could provide deeper insights into the complexities of technological adaptation in warfare.

Geographical Gaps: While the studies provide valuable insights into the impacts of technological advancements on warfare tactics in Western countries, particularly the United States and European nations, there is a significant gap in understanding how these technologies influenced warfare in non-Western contexts. For example, Brown (2021) and Williams (2019) primarily focus on Western naval and infantry tactics. There is a need for research that explores the diffusion of these technologies to other regions, such as Asia, Africa, and Latin America, and their impact on local military tactics and conflicts. Additionally, studies could examine the comparative effectiveness of these technologies in different geographical and cultural contexts, providing a more global perspective on the Industrial Revolution's impact on warfare.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The Industrial Revolution was a transformative period that significantly altered the landscape of warfare through a series of technological advancements. Innovations such as the steam engine, rifled muskets, railways, ironclad ships, telegraphy, machine guns, and mass production techniques collectively revolutionized military logistics, tactics, and strategies. These technologies enabled more efficient troop movements, enhanced communication, increased firepower, and introduced new forms of naval and land warfare. While the immediate effects included more rapid mobilization and decisive victories on the battlefield, these advancements also necessitated extensive adaptations in training, strategy, and military organization. The period highlighted the critical interplay between technological innovation and military effectiveness, demonstrating that technological superiority could drastically alter the outcomes of conflicts. However, the integration of these technologies also posed challenges, including logistical complexities and the need for new tactical doctrines. Understanding the profound impact of these advancements during the Industrial Revolution provides valuable insights into the continuous evolution of military technology and strategy, underscoring the importance of adaptability and innovation in modern warfare.

Recommendations

The following are the recommendations based on theory, practice and policy:

Theory

Future research should focus on developing comprehensive frameworks that integrate multiple technological advancements to provide a holistic understanding of their combined effects on warfare tactics. These frameworks should consider the interplay between various innovations such as transportation, communication, and weaponry to offer deeper insights into the transformational dynamics of the Industrial Revolution. By examining how these technologies interacted and influenced each other, scholars can better understand the overall impact on military strategy and tactics. Additionally, this approach will help identify patterns and commonalities that can inform contemporary military innovations. A more nuanced theoretical model that accounts for the synergies between different technologies will enhance our understanding of the complexities of technological integration in military history.

Practice

Military institutions should design extensive training programs that focus on the integration of new technologies. These programs should cover the operational use of technologies such as steam engines, telegraphs, and machine guns, ensuring that military personnel can effectively utilize these tools in strategic planning and battlefield tactics. By learning from historical examples where technological advancements necessitated new tactics and training methods, contemporary military organizations can better prepare for the integration of modern technologies. Practical training that emphasizes adaptability and innovation will ensure that armed forces are capable of leveraging technological advancements to their full potential, enhancing their overall effectiveness in various operational contexts.

Policy

Governments should prioritize and increase funding for research and development in military technologies. Policies should support the continuous innovation of defense technologies and their integration into military strategy and logistics, ensuring that armed forces are equipped to face contemporary and future threats effectively. By investing in cutting-edge research, governments can foster the development of new technologies that provide strategic advantages and enhance national security. Additionally, sustained investment in military R&D will drive innovation, create economic opportunities, and maintain technological superiority in an increasingly competitive global landscape.

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