The search for self and confronting societal restrictions in the novel "The Black Boy": a critical study

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Abstract

Since the mid-1920s, American writers have largely concentrated on investigating issues of truth, deceit, and the search for social identity. The fight for racial equality has been an uphill battle for African Americans in the US, especially since independence. While some areas have made great strides in the last few decades, the problem of ethnic conflict has not. This piece showed how the South's illogical fanaticism hurts people and communities. Racial prejudice is the root cause of many of the problems that Wright and his family face. In the face of the injustices he faces, the novel's protagonist shows tenacity and a strong will to resist. Despite obstacles, he fights relentlessly for his rights and humanity in a culture that seeks to degrade him. The book delves at racism as a complicated problem embedded in society's basic structure as well as a vicious ideology maintained by evildoers. Among the most pressing societal concerns raised by this study are the novel's depictions of racism, injustice, and acts of violence. Using Richard Wright's autobiography Black Boy as a lens, this study seeks to shed light on the pervasiveness of racism and injustice in American society. The ideas and social issues explored in "Black Boy" are deeply related to critical race theory. According to critical race theory, which is a body of thought, racism and racial oppression shape people's lives in complex ways that include other forms of oppression like class and gender. **Keywords:** Critical Race Theory, Violence, Racism, Oppression, Self-Definition

البحث عن الذات ومواجه القيود المجتمعية في رواية الولد الاسود دراسة نقدية

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الملخص :
منذ منتصف عشرينيات القرن الماضي، ركّز الكُتّاب الأمريكيون بشكل كبير على التحقيق في قضايا الحقيقة والخداع والبحث عن الهوية الاجتماعية. كان النضال من أجل المساواة العرقية معركةً شاقةً للأمريكيين الأفارقة في الولايات المتحدة، وخاصةً منذ الاستقلال. وبينما أحرزت بعض المناطق تقدمًا كبيرًا في العقود القليلة الماضية، لم تشهد مشكلة الصراع العرقي أي تقدم يُذكر. أظهر هذا البحث أثار التعصب غير المنطقي في جنوب الولايات المتحدة . يُعدّ التحيز العنصري السبب الجذري للعديد من المشاكل التي يواجهها كاتب الرواية رايت وعائلته والظلم الذي يواجهه، وكيف يُظهر بطل الرواية إصرارًه وإرادةً القويةً للمقاومة ضد قيود المجتمع . ورغم العقبات، يُناضل بلا هوادة من أجل حقوقه وإنسانيته في ثقافة تسعى إلى إهانته. تتناول هذه الرواية العنصرية كمشكلة مُعقّدة متأصلة في البنية الأساسية للمجتمع، بالإضافة إلى كونها أيديولوجيةً شريرةً يُحافظ عليها الأشرار. ومن بين أكثر الشواغل المجتمعية إلحاحًا التي تُثيرها هذه الدراسة تصوير الرواية للعنصرية والظلم وأعمال العنف. خلال سيرة ريتشارد رايت الذاتية في روايته "الفتى الأسود"، تسعى هذه الدراسة إلى تسليط الضوء على انتشار العنصرية والظلم في المجتمع الأمريكي. حيث ترتبط الأفكار والقضايا الاجتماعية التي يستكشفها رواية "الفتى الأسود" ارتباطًا وثيقًا بنظرية العرق النقدية. ووفقًا لهذه النظرية، وهي منهج فكري، تُشكل العنصرية والقمع العنصري حياة الناس بطرق معقدة تشمل أشكالًا أخرى من القمع، مثل الطبقة الاجتماعية والجنس

الكلمات المفتاحية: نظرية العرق النقدية، العنف، العنصرية، القمع، تعريف الذات

1. Introduction

On September 4th, 1908, Richard Nathaniel Wright was born in a one-room shack in Roxie, Mississippi. Being born to a black family in a rural town in the post Reconstruction South meant he was a target for discrimination. He belonged to a family that was both poor and uneducated. His father deserted the family when Richard was very young. His mother was a school teacher at a

black school, a job that was difficult to find in the South but little more than a pittance. She struggled for years to keep Richard and his brother but lost her job when Richard was eight years old. That eventually led to an unending chain of hardships. In the face of extreme poverty, hunger, oppression, and death, Richard struggled to survive and obtain an education in a world that was doing its best to deny him these basic rights. This `Black Boy` is a true autobiography that tells the true history of Richard Wright's life from the time he was born to sixteen, such as his family life, psychological development, emotions, and aspirations (S. Sasa and K. BenLahcene, 2011). The slave narrative, the predominant black literary prose genre in the United States, contributed to the formation of an African-American identity while consistently influencing black narrative techniques and subjects throughout the 20th century. Afro-American literature delineates the traumatic events, suffering, and degradation that Black individuals have faced throughout their history. Racism, convention, culture, enslavement, and freedom are prevalent topics in literature. Black Literature is a contemporary subgenre of American literature that has developed in recent years. Black Americans have utilized novel writing to articulate their suffering caused by racism to a global audience. The historical context of the denial of equal treatment in society fostered disillusionment and unhappiness among the black population. Wright's struggle was against the subjugation of Black individuals by White individuals and the inequitable American society. His purpose was to seek a resolution to racial issues while promoting the concept of democracy, as he claimed to have been a victim of White tyranny and oppression, akin to other Black individuals. Richard Wright was one of the most prominent African-American novelists of the 20th century, addressing sensitive racial topics during a challenging age. He attained prominence by his artistic expression linked to the social consequences in the United States and the realities faced by African-Americans as an oppressed minority. He addressed the shortcomings of African Americans in American society in his writings, indicating the emergence of the cultural renaissance

of African-American literature. It facilitated the emergence of new theories by garnering support for the Harlem Renaissance, which advanced the interests of black intellectuals to foster artistic development and implement successful social changes. Richard Wright's literature is distinguished and artistic, yet it also contests societal standards. The conventions of the White population, repudiated by the Black community via their estrangement from the established order, are shown in Wright's works. Following the Harlem Renaissance, approximately in the 1930s, the era of Richard Wright commenced and persisted until the late 1950s. Richard Wright's novels and writings illuminated the experiences of black individuals, significantly altering American culture. Wright's novels asserted that history might serve as a form of punishment. Richard advocated that literature by Black authors should expose the social disenfranchisement of Black individuals and strive for the attainment of social equality. Stoneberg supports this by stating,

Wright, as an African-American writer, frustrated by the lack of social gains of the 1920s and 1930s and also influenced by Marxism, falls into this category of adopting naturalism in his novel *Native Son*, to reveal the social structures that disadvantages black people (Stoneberg Michael Richard, 2010: pp. 2-3).

Wright's sensitivity to African-American existence is profoundly influenced by his background in the southern United States. In Black Boy, he articulates his perspectives on African American life in the United States.

Whenever I thought of the essential bleakness of black life in America, I knew the Negroes had never been allowed to catch the whole spirit of Western Civilization that they lived somehow in it but not of it. When I thought about the lack of culture in black life, I wondered if clean, positive tenderness, love, honor, loyalty, and the ability to remember were things that came naturally to all men, not just black people. (*Black Boy*, p.35).

This paper analyzes the important of social problems and self-definition with reference of *Black Boy* novel. Our objective is to demonstrate that Racism and oppression are essential themes in

Black Boy, especially given that the book was published during the Jim Crow era.

2. Literature Review

The problem of black identity and the resistance to it in a culture that is predominately white in the United States was the subject of a study that was conducted by Diwakar Tiwari (2017). African Americans are the offspring of a past that was not without its share of challenges and difficulties. Their worry is with their identity. Dreams and nightmares are something that they experience. In the 1920s and 1930s, a period of time known as the Black or Harlem Renaissance began, which resulted in the birth of a large number of writers who championed Black culture. A writer named Richard Wright is responsible for leaving a long-lasting impression on readers with his depictions of African Americans who are in a difficult situation. In light of this, a new generation of African American writers has been given the opportunity to investigate information that was previously unknown regarding discrimination against persons of African descent.

Furthermore, another study by Febrian Ramadhani Setiaji (2019) examined This study aims to clarify the depiction of American hunger in Richard Wright's novel Black Boy. This study is a qualitative analysis that relies on the effectiveness of verbal or explanatory reasoning. The data was obtained by reading, identifying, classifying, and analyzing through the use of structuralism theories in this study. Binary operations were utilized to analyze the differences between black and white societies. The study demonstrated a distinct division between black and white individuals regarding treatment, authority, and dominance, finally indicating that black individuals experience differential treatment and are deprived of freedom. The novel illustrates American Hunger via episodes of confrontation between black and white folks. The friction between them stemmed from the unequal treatment, oppression, discrimination, superiority, and deprivation faced by black and white individuals or society. The dominance and power of white

folks have adversely affected black individuals in various aspects of their lives.
The work portrayed American Hunger as the yearning of Black individuals while cohabiting with white individuals in America. When discrimination, segregation, and oppression target black individuals, they confront their American hunger by opposing racial subjugation, fortifying their resistance, and combating injustice.
According to research by Rajendra Prasad Bhatt (2022), Black Boy by Richard Wright depicts African American life. It delves into the ways in which Black Americans feel oppressed and how societal and cultural issues play a role in this. The novel "Black Boy" is primarily a criticism of the racist white society in the South; it depicts extreme poverty and the author's personal encounters with racial violence against Black people. Black American experience, with an emphasis on sexism and racism, is the subject of this narrative inquiry study. The persecution of Black people by dominating whites, the internal strife and bloodshed inside Black communities, and the struggle between Black and white communities are recurring themes in Wright's writings. In order to counteract Black community pride and self-identity, this dissertation contends that Black American literature combats racism and injustice. Various factors from the past and present, as well as individual and cultural viewpoints, impact the continual process of seeking one's identity.

3. Overview of the Genre's historical context

Since the signing of the Declaration of Independence, African-Americans in the United States have battled for racial equality. It has not been an easy journey. The country has made significant progress in eradicating racial disparity in recent decades, but no one believes the problem has been fixed. *Black Boy* is one of the most captivating records about an artist's struggle to discover his or her individuality and achieve success in the American music industry. Between 1908 and 1927, when Wright was growing up in the South, *Black Boy* unquestionably aimed the systemic Racism that pervaded society. Racism

played a significant role in many of Wright's family's difficulties, both directly and indirectly. Wright discovers prejudice to be ubiquitous and unbearable once he enters the world of employment. In this way, Wright's autobiography comes to a close with his flight to the South and the discriminatory conditions he is forced to face there. Anthropological notions that have already been disproved have given rise to the concept of a "racial group". This school of thought originated predominantly in Western Europe in the 19th century and early 20th centuries, asserting that humans could be separated into racial groups based on physical and behavioral features related to ethnicity, nationality, and associated conceptions such as a shared language. The present use of the terms "race" and "racial" emerged due to these false conceptions of Racial discrimination is growing ingrained in society's attitudes and behaviors, particularly in Western nations. These views penetrate all aspects of Scottish culture, from social attitudes to organizational structure, disadvantages experienced by Black and minority ethnic people are perpetuated over generations. 'Race' is inextricably tied to skin colour. White populations worldwide have not been 'racialized' in the same manner that non-white people have been. Their process of racialization resulted in more benefits than problems. As a result, while there may be prejudice and discrimination against white minority ethnic groups in Scotland, we would classify this as xenophobic prejudice rather than racist. One of the most common ways to describe oppression is as a malevolent or unjust use of power. In the context of discrimination, oppression occurs when a wrong is committed against a specific group of people rather than the general public at large. There is currently no widely accepted paradigm or terminology for explaining oppression in its whole, although some academics have found sign of numerous varieties of tyranny, including social oppression, institutional oppression, and economic oppression, among others. When one person forces their will on another, this is called oppression. However, the concept, popularized by

Marx and Engels in their 1848 Communist Manifesto, is frequently invoked to justify governmental repression.

However, the Latin word oppressus is the past participle of opprimere, which means to make someone feel bad or ("to press against", "to squeeze", "to suffocate"). In other words, when governments use tyranny to make people subservient, they want their citizens to feel that "pressing down," and to live in fear that if they displease the government, "squeezed" and "suffocated," for example, they'll be put in a dank, dark, state prison or killed. Such governments use restraint, control, terror, hopelessness, and despair to make people feel hopeless and helpless (American Heritage Dictionary, 2016). Taylor (2016) described (social) oppression as a more insidious kind of manipulation and control:

Oppression is a form of injustice that occurs when one social group is subordinated while another is privileged. Oppression is maintained by a variety of different mechanisms, including social norms, stereotypes and institutional rules. ... Oppression] occurs when a particular social group is unjustly subordinated, and where that subordination is not necessarily deliberate but instead results from a complex network of social restrictions, ranging from laws and institutions to implicit biases and stereotypes. (Taylor, Elanor, 2016).

In particular in Western countries, racial differences are becoming ingrained in society's views and behaviors. As a result, persons in positions of relative power can treat and exploit a group of individuals in a socially acceptable manner. Social group oppression can be founded on a variety of ideas, such as the opinion that people are oppressed based on their socioeconomic status or the conviction that people are oppressed based on their ethnicity. the concept of racial oppression or discrimination is defined by the term "race.":

" ...burdening a specific race with unjust or cruel restraints or impositions. Racial oppression may be social, systematic, institutionalized, or internalized. Social forms of racial oppression include exploitation and mistreatment that is socially supported."(Wikipedia,2021).

4.Critical Race Theory

It is commonly believed that Derrick Bell is the person who established Critical Race Theory. The creation of Critical Race Theory was significantly influenced by Derrick Bell, a pioneering legal scholar and civil rights activist who played a crucial role in the process. His work posed a challenge to conventional legal frameworks and placed an emphasis on the part that race plays in the formation of US laws and institutions. With his contributions to Critical Race Theory, such as his concept of interest convergence and his use of storytelling as a vehicle for social critique, Bell has left an indelible mark on the field, and his ideas continue to have an impact on academics and activists who are working on issues pertaining to race and social justice. Critical Race Theory (CRT) is a theoretical framework that originated in legal studies in the late 20th century and has been utilized in several fields like as sociology, education, and cultural studies. Critical Race Theory aims to analyze and question how race and racism interact with systems of power, institutions, and cultural standards. Here are some essential aspects of Critical Race Theory: Critical Race Theory (CRT) is a theoretical framework that originated in legal studies in the late 20th century and has been utilized in several fields like as sociology, education, and cultural studies. Critical Race Theory aims to analyze and question how race and racism interact with systems of power, institutions, and cultural standards. Here are some essential aspects of Critical Race Theory: 1. Origin : Critical Race Theory emerged in the legal sector throughout the 1970s and 1980s, mostly among scholars of color who questioned conventional legal methods regarding race and discrimination. Key figures in the advancement of Critical Race Theory (CRT) are Derrick Bell, Kimberlé Crenshaw, Richard Delgado, and Patricia Williams. 2- Critical Race Theory highlights the interconnectedness of race with other social categories like gender, class, sexuality, and nationality. This approach acknowledges that individuals might face various types of oppression and privilege at the same time. 3- Critique of Colorblindness: Critical Race Theory questions the concept

of colorblindness, asserting that disregarding race does not eradicate racism but instead sustains systemic disparities. CRT supports recognizing and dealing with racial inequalities and prejudice. 4. Interest Convergence: Derrick Bell proposed the idea that racial advancement is most probable when it coincides with the interests of those in authority. This theory emphasizes the strategic factors that impact social change. 5- Counterstorytelling is employed in Critical Race Theory to confront prevailing narratives around race and racism. Critical Race Theory aims to challenge dominant power systems and elevate different viewpoints by focusing on the voices and experiences of oppressed people. 6. Structural Inequality: Critical Race Theory analyzes the presence of racism within societal frameworks, organizations, and regulations. It emphasizes how power structures sustain racial inequalities by favoring some groups while putting others at a disadvantage. 7. Critical Race Theory is frequently linked with action and advocacy for social justice. Those involved in Critical Race Theory want to utilize their research and analysis to advance racial fairness, confront institutional racism, and support legislative reforms that tackle racial inequality. Critical Race Theory offers a critical perspective for examining and comprehending the intricacies of race relations, power structures, and socioeconomic disparities. It has had a significant impact on shaping conversations around race, law, education, and social policy, leading to crucial talks about structural racism and the necessity for radical change.

5.Critical Analysis of The Black Boy

5.1.An Introduction to Black Boy (1945)

Richard Wright's *Black Boy* (1945) illustrates the protagonist's self-education, highlighting his experiences of suffering due to racism. It depicts the image of his impoverished family in Natchez, Mississippi. It illustrates his futile journey to overcome poverty and evade racial oppression. The story chronicles his existence as a vagabond and examines the resilience of urban life. Wright was astonished by the alienation caused by

technological progress. Wright, in Black Boy, illustrates the lethal impoverishment perpetrated by Whites as a systemic means of subjugating Blacks. *Black Boy* illustrated the disruption produced by racism, whether on an individual or collective scale, as a reality in the South. The story elucidated the mundane and inscrutable conditions of living in the South. It revealed the brutal conditions of blacks, illustrating famine as a pervasive affliction inside society during the Great Depression. Both white and black cultures are portrayed as elaborately constructed narratives of racial virtue that thrived on the denigration and vilification of black masculine figures in the works of Richard Wright. The legitimacy of White culture, which asserts its superiority over Black culture, is highlighted by the disparity between its harsh realities of abuse and deprivation and its rhetoric of justice, opportunity, progress, order, and rationality; consequently, the Black population remains marginalized. The purpose of this exposure is to reveal the mismatch between the ideologies of White culture and its practices concerning Black individuals. It further challenges the specific epistemological and theoretical foundations of Whiteness, serving as evidence grounded in both an essentialist and affirmative view of the self and the other. According to Wright's depiction, black manliness is an identity in crisis, since it fundamentally contradicts the humanistic paradigms of power and knowledge that underpin White frameworks of social normativity and racial cohesion. The White civilization and its implicit enlightenment assumptions are scrutinized and contested through Wright's fiction, which illustrates how the black male surpasses the typical white individual. The belief that Whiteness cannot withstand scrutiny in revealing its epistemological assumptions and that facts are not inherent but constructed and convoluted exemplifies its exploitation of fractured Black masculinity. Abdul Jan Mohamed (1995) delineates a prevalent method of identification, wherein the rupture and distortion of the black subject become a locus for examining White culture's differentiation in the construction of knowledge and values.

Wright's main scholarly distraction of comprehending his own particular arrangement as a black subject by White as well as black cultures is also contended by Abdul Jan Mohamed:

All groups define their identities through some form of binary opposition to other groups [and] the very process of suturing the (relative) 'homogeneity' that is crucial to the definition of that group's 'identity' . . . also simultaneously constitutes the process of rupturing various subjects on its borders the border subject becomes the site on and through which a group defines its identity. (Mudimbe-Boyi, 2012: pp.231-32).

While the roots of racial identity are linked to American history and social practices, Wright transcends this focus, employing it as a metaphor that displaces both White and Black identities from essentialist interpretations of reality, situating them within the historical context of a racial struggle for meaning and power. In a distinct context, he interrogates White identity, asserting that, akin to the Negro, it is a "construct" and a product of societal developments. He explains how African-Asian pioneers in the postcolonial time see Whiteness:

The 'White man' is a distinct image in Asian-African minds. This image has nothing to do with biology, for, from a biological point of view, what a 'White man' is not interesting. Scientifically speaking the leaders of Asia and Africa know that there is no such a thing as race. It is, therefore, only from a historical or sociological point of view that the image of 'White man' means anything (McKenna, 2015: p.239).

'Black Boy' is the autobiography of Richard Wright. It illustrates life in the southern and northern regions of the United States. As an African American residing in the Jim Crow South, this is the experience. The tale commences with the father's presence in the household and the protagonist's reflections about him. He stated that his mother was a devout black woman who harbored significant apprehension towards the white individuals in her vicinity. The protagonist's father deserts the family, rendering them susceptible to the ramifications of poverty. This exerts a significant strain on Richard's mother, who, unable to endure the burden, falls ill. The protagonist's harrowing existence,

oscillating between households for sustenance while nurturing a passion for literature, is elucidated. The significance and nature of the schooling prescribed by Whites for Blacks is effectively depicted in the narrative. Richard, unable to endure the circumstances in the South, ventures to the North in hopes of discovering improved living conditions and fortune. Upon arriving in the North, he comprehends the harshness of reality when he discovers the prevalence of White supremacy, employment discrimination, and racial segregation in the ostensibly liberal North. The autobiographies of his contemporaries, Zora Neale Hurston, Maya Angelou, and James Baldwin, illustrate their life experiences, detailing the expressions of what life presented to them and the diverse circumstances they encountered. Richard Wright labels his piece Black Boy primarily to emphasize the word black. This narrative chronicles Wright's adolescence, while the color of his skin perpetually occupies his thoughts. He is maturing in America as an individual of African descent. Due to his skin tone, white individuals in the story consistently treat Richard unjustly in most encounters. Subtle racism was of greater significance to Richard Wright as it hindered his ability to frequently connect with Whites who saw him similarly (for example, the Hoffmans or Mr. Crane) or with other Blacks. Wright's research on racism in America includes an examination of the black community, which, particularly the black societal group, was reluctant to provide him with adequate education. The brutality of fictitious characters in contemporary American literature reflected his own dissatisfaction upon realizing the creative potential of literature "I vowed that as soon as I was old enough, I would buy all the novels there were and read them to feed that thirst for violence that was in me, for intrigue, for plotting, for secrecy, for bloody murders" (Rowley, 2008: p.10).

5.2.Themes of Identity and Self-Discovery

There are several major themes in Richard Wright's _Black Boy_, a memoir detailing his early life in the oppressive

environment of the Jim Crow South. One of the most prominent is identity, especially the searching for one's own identity against the societal forces that try to dictate existence. Many people are relegated to a smaller existence as part of a greater whole, morally and materially limited by a society that denies them freedom to be themselves or to aspire to all that they might hope to be. Wright's childhood is spent trying desperately to exist as an individual in a world that fears him as an individual, a world that only wants him to live as a part of a collective having neither thoughts nor desires beyond what is deemed acceptable. In the novel, this searching for identity transcends the plotlines that dictate its events, grounding them with meaning and energy larger than their limited concerns. Perhaps the best illustration of the theme of identity comes during the scene where Wright agrees to take part in a boxing match against another black boy for the amusement of a white audience (Hudson, 2008). Now that the predominant audience in Wright's world is black, he can afford to perform in the role of the individual, taking upon himself the challenge of thinking and acting out a creative and exalted vision of the world outside the confines of White society. The amateur boxer that Wright plays is given the freedom of existence, able to express feelings of power and greatness. To the extent that he does rise above the restrictions that had formerly bound him, he has triumphed in his struggle for identity. In the sight of the audience, Wright is a boxer, a host of indeterminate possibilities and energies, whose intentions extend beyond the righteous anger to strike that bubbled with the death of Granny and detonated publicly at the thought of stepping on a dog's tail. Wright eventually wins the match, much to the confusion of the black audience and to the delight of the whites (S. Sasa and K. BenLahcene, 2011). For Wright, a sense of self endowed with firm opinions about the world outside the accommodating South made itself unavoidably necessary. His first hurried sprint from the beatings of school led to the realization that he could live only if he wrote, whether or not anybody ever read what he wrote. Whereas Wright had referred to the feverish shame over

Granny’s proxy kneeling in the place of a black church, now a volley of energies and insights pounded in his mind against the quiet deliberations of the black community, and dreams of whisking them out of himself to return heavy with the products of a fresh understanding took shape around the hope of more worldly and bitter years in the North.

5.3. Societal Restrictions and Their Impact

Unlike Meursault, Richard is subjected to innumerable restrictions imposed on his individuality and his quest for self. What Richard regards as 'fighting' appears to be an unending job of disconnection, self-examination, detachment or bracketing, much like scientific scrutiny, from which he can only escape through conformity or camouflage. The success of his camouflage during childhood gives no satisfaction; his victory over the predicaments of his life is meaningless (S. Sasa and K. BenLahcene, 2011). Richard is forbidden to dabble in writing. He is ridiculed and highly despised for being different, an ancient difficulty with originality. Richard gets a slight relief when he finds his childhood confidants, his writings. They offer him a rare material beauty and lift him above the sordidness of his hard life as well as his future. In the course of fighting, he learns for the first time about death and its cause. He learns how men cause each other's death and unmask the terrible cruelty of man, even his young ones. But the success of the fight offers him no pleasure. What is great about such a venture but that it is wanton? by the same token, Richard is bewildered by his mother's determination to make him happy on Christmas day with a revolver. Richard realizes that such is the nature of adult happiness. Richard learns the arbitrary relation of his body to his fate. That Richard does not understand what reverberates so profoundly in his heart is particularly telling. Richard's feeling is unformed and indeterminate before he sees this terrifying phenomenon but the meaning of this perception is utterly lost. Richard understands that education is wearing and guidance 'an ineffably complex matter.' Though his perspective has been transformed radically and ' life in its light was fearful,' he is lost

and the world is more intractable than ever. Physically bruised, psychologically disrupted, and cognitively disoriented, Richard is as far away from life as in the beginning. It is as if Wright experienced a radical alteration of the natural thesis, for which a remembering of life, self, and society should be anew (Hudson, 2008). In theory, remembrance would require a continuing procedure of disconnection or bracketing. But the rich lives of Wright's family and community make it improbable that the remembered lives were examined and excavated individually. On the contrary, it seems that such an outpouring went like scientific scrutiny. This is singular as it purports to be the showcase of social vignettes carefully arranged. Wright is forced to perform the role expected of him by the democratic white audience.

5.4. Racial Dynamics in the Narrative

Richard displays both his desires and aspirations for the future and a reason for his oppression in the narrative. From the time he is made aware that he is black, he is abandoned to the racial hatred of the South and forced to internalise hatred towards his blackness, which would “bug” him for the remainder of the narrative (Hudson, 2008). Despite the youth’s realisation of dreams fulfilled through education and the desire to be privy to the musings of writers, he attempts to flee precisely this potential arising from his identity. For doing this, he would be forced to wrestle with himself and the desire to be free, since this entails damaging beige fantasies: the notion that the Southern black youth can escape this colour. However, Richard’s acceptance of his blackness, precisely this wish to be free and strive for his aspirations is incommensurable with both Southern white society and their view of race. For this is the very essence of that view, that Richard cannot have this, and society may beat him down and destroy him “so long as the height of the concern built on his skin prevails”. Further underlying this unease is truth: wounding colour, that for the time that racism persists no heterosexual black man is free. The narrative states that speaking black is not a choice on his part

but an inevitable result of forced education, and his aspirations of painter and musician have come under scrutiny since these would not be 'honest' professions. Richard, now fully aware, attempts to mitigate this essence of being black: as though no longer seeing it as the prize fought for at length. Though Richard accepts the truth of his colour and takes positions on issues, being black does not travel unquestioned into this new future; nor are the tenets of Southern racism interrogated. For initially, Richard embeds his blackness within a Southern semiotics untouched by wider forms of prejudice and exploration of the stature of the colourline. Yet the need to play and win boxing matches for white audiences recalls the grotesque, a trope used to explore difference since it is made strange through portrayal as 'other' and is invoked to express frustration and fury in otherness. Richard's blackness is questioned first on account of its changeable fairness and purity, movements of the grotesque which deal with otherness. Yet, as the semiotics of struggles around being black shifts to embodying difference, all that is written serves as reinforcement for only black narrative. Richard's blackness returns to its Southern questioning, but now embodied in more intimate selfhood and interactions with the brutality of black life, unrecognisably as pre-existing styles of the grotesque.

5.5. The Role of Family in Self-Perception

Richard Wright's narrative of struggle and survival in his autobiographical work 'Black Boy' deals with a formative stage of his life, lasting from about the age of four until he was seventeen, in which he lived in the South. The book illustrates a world where one individual is essentially an alien in a traditional society and a protagonist isolated by his quest for the meaning of life. Society controls humanity. Black Boy is a life story and an exploration of the quest for self that unfolds in a societal milieu that imposes restrictions. Through content as well as style, self and society cannot be mediated. Wright employs denotation, literary allusion and premonition. His style is devoid of a mature self that could render obliquely his childhood, as it

is quintessence. In the beginning a boy observes situations and the role of the adults. Society imposes rigid rules. A man of action, able to instill terror in others, fascinated Richard, submerging the black naïve boy into a world of adult men. Then terror struck back, confirming the foreboding and foreshadowing the intensity of moral conflict. The next period of life, the blacks' invisibility from the white world, waves of fear, anxiety, and sincere but naïve questioning. Again, perception of divergent levels: How different clothes and money could give one equality. The inquiry nervously danced on the edge of consciousness. It gradually recedes from the childhood perceptions of nature as abiding, adhering to consciousness as a sum of parked memories. Society becomes synonymous with an oppressive white world. The capture of adulthood, urban experience, and the choice of art was sketched through moral choices, probing each side of a scaling moral dilemma. As the white world came into prominence, the life of Richard Wright's formlessness on an alien self—a black boy from the South turned into a local pariah in Harlem, periphery of periphery, seeking a self in the dark of the subway even in the self-aware state.

5.6. Impact of Environment on Identity Formation

In his autobiography, Black Boy, Richard Wright depicts the oppressive environment of the South and its results on black men. Richard's recollections of his childhood enter the consciousness of the reader through a gradual awakening to his race and the hatred associated with it. Black Boy is not only an autobiography: it is an examination of the effect of a racially oppressive environment on the identity of a black individual. Richard's societal conditioning is due not only to the general oppression that all black people endured but also to his particular upbringing. Moody, a racist teacher, attempts to change Richard's default methods of survival through a series of cruel punishments for being black and resisting white authority. Divorced from the concept of colour till this point, Richard must endure the scorn of a society that privileges by birthright. By

expertly painting the destructive power of racism, Wright exposes how Richard achieves a conscious identity in spite of it by purchasing his authenticity through blistering suffering. Black Boy begins with child-like naivety in a spatially confined South. Over the course of Richard's recollections of his childhood, he undergoes a long maturation process resigning in total voluntary exile from the South. The novel ends with Richard bursting out, 'I was really free. I was me'.

Richard's internal conflict under his oppressive environment seething with hatred leads him on a path of self-discovery by searching for an undefined self. With a sense of alienation from his world and dissatisfaction with his social role, Richard strives to construct a conscious subjectivity to overcome it. In doing so, he must leave home and sever emotional ties with those holding him back by sacrificing his childish innocence and obtaining knowledge of sex and of society as the cruel white-man's world. He must collect aesthetic memories to preserve the child's world while constructing his own. It is this continual good-bad dance between worlds that creates Richard's struggle.

5.7. Character Analysis: Protagonist's Journey

The protagonist of the autobiographic novel sets a journey: to find a place where he can be free or where he can become himself in the full sense of the word. He finds himself surrounded by a family that makes him feel unknown and unrecognized. The grandmother is one of the symbols of restrictions in the novel. The description of her reveals the claustrophobic nature of her religion. She is portrayed as a woman who tears her heart, physically and emotionally touches her god with intense feelings. Thus, she is an extraordinary fanatic believer who believes in rapture and spiritual ecstasy. The firm grip with which she holds her religion does not only stem from naivety, ignorance, and compliance. Rather, it originates from a shame that grows inside and around her violent existence. She had deadly sins; she is black and poor in a powerful and racist society. A place of god and prayers – the only hope – provides a compensative world where mundane and

profane practices are vanished to a less visible state. But it is obvious that prayers can hardly fill up this inner emptiness. The fanaticism stirs the fears born with trauma up to a terrifying state, which controls her every time, and thus becomes, in a sense, stress relief or the evocation of inner horror. Eventually, the protections offered by the religion transform into restrictions that determine one's identity deeply. The invalidation of her self, desires, memory, the world's secret and truth bring complaints that either reveal the fragility of her existence or fuel the anger towards black people who live as animals. The submission and hatred are projected towards her family with a perverted compassion. Ironically, this blindness enables the blacks to bear the violence and traumas from others.

The other figure limiting his freedom is the father. He is a shadowy presence that does not appear frequently but has a strong impact on the son. His violent actions and disappearances torment him a lot. The uncertainty of being attacked or abandoned creates extreme anxiety reflected in many hallucinations of being hunted and threatened by family members. His physical strength functions as an interest for those who emotionally and physically abuse other blacks. Thus, he embodies the deep-seated fear of being oppressed or mishandled by the other. He awakens an unrelenting hatred towards men who embody oppression. The father's invisibility cruelly disproves the possibility and hope of being independent and freed.

5.8. Gender Roles and Their Implications

Society defines gender roles and tends to impose them rigidly, leading to stereotyped behaviors expected from universally accepted male and female identities. Gender role or sexuality is a social and cultural phenomenon, focusing on the roles, positions, and expected patterns of behavior of individuals based on their gender or sex. Gender-based stereotypes show how society expects males to behave "masculinely" and females to behave "femininely." All societies encourage certain appropriate behaviors and activities along gender lines, emphasizing sexual

dimorphism. Gender roles define the different roles men and women are expected to play in society in terms of emotion, behavior, interest, and ability. Gender roles are socialized through families, schools, peers, mass media, and religious institutions. As a consequence of socialization, men are seen as assertive and dominant, while women are seen as passive and nurturing (Rodriguez, 2019). Boys have toughened hearts. Being a boy means being hardened against women and girls, even against love, affection, or emotion in general. A boy may hug his friend, but usually only in absence of touch unless it is perceived as playful and as teasing. The danger of figuring masculinity in aggression, danger, violence, and fighting raises fear in the hearts of mothers. Having a boy means feeling fear in sending him out in the world and much more at the prospect of him growing up. Boys regard crying, softness, gentleness, fear, and affection as shameful things. Ironically, by turning away from softness, they tend to act cruel to the softer members of the society – women, children, and weaker boys. They avoid playing dolls, rock-paper-scissors, or anything that involves gentleness at all. Subtle, caveman-like versions of "Kick!" and "Throw that!" take over every game. Violence starts to feel normal (Hudson, 2008). The world in general, and adulthood in particular, seems to be much more dangerous for a girl than for a boy. Moments of helplessness, fright, sadness, reliance, and weakness turn into a thought form "Am I weak?" At playground, streets, and roads, girls learn to be harder on little under-tens, embracing such masculine traits as aggressiveness and toughness. It seems to become impossible to cry the tears of weakness, instead forming cold anger, silence, or indifference. Emotional expression becomes more complex, and any moment of anger seems to put everything and everyone, even the dearest ones, at a stake.

5.9. Race and Color

Among African American authors, Richard Wright gained prominence for works that dealt with the economic and social intricacies of America and the oppression of Black Americans.

In his writings, Wright addressed the problems that Black Americans faced in modern America. An African-American man's fight for self-discovery and liberation from societal constraints is a central theme in Richard Wright's writings. In his writings, Wright addressed the problems that Black Americans faced in modern America. An African-American man's fight for self-discovery and liberation from societal constraints is a central theme in Richard Wright's writings. Furthermore, the novel *Black Boy* focuses on the lives of Wright and his encounters with whites, his neighbors, and his own family during the Jim Crow era. Several such instances of *Black Boys* responding to abuse by calling their abusers names unbecoming of a civilized society have occurred. It is clear that the work was written during the time period when the Jim Crow Laws were in effect. Because of the establishment of Jim Crow Laws, the black community suffered greatly as a result. When young Richard was out running errands for his mother, he was in a very different environment where violence would recur in his life. It was commendable how Richard Wright depicted the terrible violence he witnessed as a child. He was one of the first writers to focus only on the horrors of the Jim Crow Laws and Racism in the South, which led to the commencement of the American Civil War without his knowledge or consent. He built a reputation for himself and was a trailblazer in the fight to end all types of violence and racial discrimination perpetrated against the black people in America, including police brutality and segregation. As Jan Mohamed concludes his essay :

Black Boy is remarkable not so much for its rebellion as for the control that Wright had to exercise and the internal struggle that he had to wage against being engulfed by the racist sovereignty. (Rampersad, 1995, pg. 118).

The color of the skin does not affect or correct the minds, but makes the victims of hatred more open or violent, is precisely reflected in the novels taken from Racism and the persecution of black subject, among these novels *Black Boy*. It is exactly what the stories of Racism and black oppression are inculcated. These include novel *Black Boy*, which highlights on racial

discrimination which based on color and race. The novel is giving a voice and support to the formerly voiceless black youths of the South. Richard Wright's autobiography examines the manner in which the South's racial landscape shaped its inhabitants. Individuals found it exceedingly difficult, in an oppressive society, to free themselves from the shackles placed on them by the community and rise above it. Richard, on the other hand, prevailed despite his ferocious will. Interestingly, Wright himself stated that he wished to pass judgment on his surroundings: 'This judgment was this: the environment the South creates is too small to nourish human beings, especially Negro human beings.'(Andrews, 2003.pg 134). This is clear in his judgments of many black persons in his immediate environment. Wright does not feel completely at comfortable in either white or black society; yet, he does feel at peace in both, he is a man 'estranged from his own race by sensitivity and intellect, yet segregated from the white race by the colour of his skin.'(pg.140). He also attributes his predicament to his surroundings, the oppressive climate of the South: 'The shocks of southern living had rendered my personality tender and swollen, tense and volatile' (*Black Boy*, p.260). Wright was physically and verbally abused and threatened by his own family throughout his whole youth. When he was four years old and accidentally sparked a fire in the house, his mother beat him mercilessly. According to Yoshinobu Hakutani, 'It seems as though black adults, subjected to racism in white society, in turn felt compelled to rule their children at home.'(Bloom, 2006,pg.90). The majority of Wright's black population allows white supremacists to impede their quest for self-expression and identity development: ''I began to marvel at how smoothly the *Black Boys* acted out the roles that the white race had mapped out for them" (Feagin,2014, p. 60). However, Richard was involved in some capacity in this before he realized his error. This story involves Richard agreeing to fight a black kid for the amusement of white people at one point. 'I suppose it's fun for white men to see niggers fight… To white men we're like dogs or cocks' *(Black Boy*, p. 239).

6.1. violence and Hunger

The violence in *Black Boy*, whether bodily or otherwise, is extremely vital, because it is what makes the authority have a tendency to depend on rather than argument. According to the beliefs of Wright, the succession of arguments has to be based on their own merits but not to violence or appeals to authority. A world that is quick to depend on force in order to meet the challenges can easily be determined by the reader of what Wright thinks. Wright is beaten so severely and for such a long time that he passes out, after the house was set on fire. His grandfather, Aunt Addie, grandmother, his mother, and other family frequently lash, slap, and beat him. He is also bullied at school. His uncle Hoskins, whose prosperous saloon business was envied by the Whites, was the target of their assassination. In order to protect himself from his aunt Addie, Wright pulls out a long bread knife on her and his Uncle Tom is also threatened with razor blades and he as well fights with other boys. These befitting examples are proof the theme of physical violence lies the threat of lynching and to say that violence is everywhere in *Black Boy*. Hunger is a prevalent motif in Black Boy, including the need for chance, education, love, life, and sustenance. The final third of the original book was released in 1977 under the title American Hunger. Wright's family lacked sufficient food, leaving him perpetually hungry in the most fundamental sense. Wright, born in 1908, had to consume excessive food in the late 1920s to attain the requisite weight for a postal position. He regarded his father as a rival for sustenance, which engendered his animosity against him. Wright could both smell and observe the food when he was brought to a kitchen where his mother prepared meals for a White household, although he was permitted to consume only infrequent leftovers. He had frequently weakened from famine, rendering him unable of fulfilling his responsibilities in the yard at the orphanage where he and his brother had been abandoned by their mother. At one point, he nearly sold his poodle to get food due to extreme hunger. To artistically demonstrate to his readers that racism is always felt in everything a Black man does, Wright endures

severe hunger and suffering. Wright's children are the children of African-Americans:

…… Mama, I'm hungry' I complained one afternoon.

'Jump and catch a kungry,... she said trying to make me laugh and forget.

'What's a kungry? It's what little boy eat when they get hungry She said. ….. ……' I don't know 'then why do you tell me to catch one? I sensed that she was teasing me and it made me angry. But I am hungry, I want to eat' 'You will have to wait 'But I want to eat now' For god to send food' When is he going to send it? I don't know

But I'm hungry (*Black Boy*, p.13)

The reader is constantly reminded throughout the novel the situation in Richard Wright's family is not quite easy. One of the biggest problems was hunger. Richard (character) is taken to the cooking job by Richard's mother. When Richard's mother was preparing food, which could smell it and every now and then he and his brother managed to get some scraps:

We would watch her go from the stove to the sink, from the cabinet to the table. I always loved to stand in the White folks' kitchen when my mother cooked, for it meant that I got occasional scraps of bread and meat; but many times I regretted having come, for my nostrils would be assailed with the scent of food that did not belong to me and which I was forbidden to eat (*Black Boy*, p.17).

Following the father's departure, Richard's mother was compelled to assume responsibility for the family, despite lacking the funds to cover the rent. She successfully retained some funds from her mother; but, those funds have already been depleted, rendering her unable of purchasing food or adequately caring for little Richard and his sibling. In her quest for potential answers, his mother contemplated the problem for an extended while. Ultimately, she secured employment, tasked with cleaning dishes in the kitchen for Caucasians. The income she generated from this employment was insufficient to sustain herself and her two children. She ultimately had a difficult and convincing decision to leave her children at an orphanage

temporarily due to her circumstances. A two-story wooden structure situated in a spacious green field surrounded by trees was the orphanage where Wright's mother brought him and his brother one morning. They were introduced to Ms. Simon, a statuesque mulatto woman. She instantly developed an attraction to Wright, leaving him rendered speechless by dread. Upon seeing her, she experienced fear and trepidation that persisted for the duration of his residence in the orphanage. In this incident:

The house was overcrowded with youngsters, and there was constantly a lot of noise. The daily routine was hazy to me, and I never truly understood it. Hunger and dread were the most persistent emotions I experienced every day. The meals were little, and there were only two of them. Each night before bed, we were given a slice of molasses-smeared bread. The youngsters were silent, unfriendly, vengeful, and constantly moaning about hunger.

(*Black Boy*, p.27).

Richard Wright articulates his concerns throughout his upbringing at an orphanage. In addition to his inability to grasp the regulations he was required to adhere to, he was always famished and fearful of Miss Simon. He struggled to adapt and ultimately severed communication with his mother after Ella was notified by Miss Simon that her visits were deemed improper. Several months post-Ella's departure, Ms. Simon said that Richard experienced terrible homesickness. Upon learning that he could no longer visit his mother, Richard began to descend into sadness. Wright has an insatiable appetite for narratives and words, apart from the yearning he felt for his mother. He chooses to read or listen further, as he experiences elation at hearing the tale of 'Bluebeard and his Seven Wives' for the first time. To fulfill his want for social connection, he attended church during specific moods only to satiate this desire. He harbored an intense yearning for maternal attention, which he was never afforded. Wright's paramount desire was for life itself and the chance to comprehend it without the apprehension of rejection or violence. Wright's perspective on religion posits

that various interpretations of black Protestant Christianity serve as a mechanism of social control, which is identified as the third most significant thematic issue in Black Boy. Wright's slogan was "One World," signifying his belief in the existence of a singular planet in which we all reside. Consequently, he saw the concept of a 'other' universe as repugnant to his intellectual sense. Following the kitten's death, he was compelled to recite a prayer alongside his mother, during which he was instructed to beseech God for the preservation of his life, despite the fact that the kitten's life had not been spared. In Black Boy, religion is transformed into instruments of intimidation and aggression through various means. The immoral tenets of religion have profoundly influenced Wright, resulting in the most of chapter 4 being dedicated to this issue. While he acknowledges the emotional allure of religion, he asserts that he is enough rational to consult a physician should he encounter an angel. The application of religion in his grandmother's life, a Seventh-day Adventist who holds that Saturday is the designated day of worship and anticipates Christ's second coming and the imminent Last Judgment, was deemed unethical by Wright, who noted that his lack of faith was occasionally attributed to his mother's extended illness. Nonetheless, his comprehension of religion's role was to compensate for the deficiencies of reality, while concurrently maintaining a steadfast realism. In his view, religion constituted a distinct form of authority. He struggled to decline his mother's request due to her presentation; she asserted that he would join the church if he loved her. A fourth topic is race and racism. Wright repeatedly illustrates the total insanity of assessing one's "superiority" based on skin tone and the necessity of adopting an inferior demeanor to satisfy the social and emotional demands of lighter-skinned folks in his plays. As a kid, Wright recognized that race was a highly questionable term, particularly upon seeing that his grandmother was as White as any 'White' individual. The fundamental idea of White thought posits that an individual's worth is significantly determined by their racial affiliation, a theme prevalent throughout the novel. An illustrative example by Wright is that

it is futile to establish social divisions based on racism, despite the potentially intricate efforts to contest this reality. In his childhood, Wright absorbed the essence of written language by inscribing four-letter phrases on windows, which alarmed his mother but ultimately demonstrated to him that writing serves as a means to exert influence on the world. One day, as he was utterly fatigued in his chamber, he penned a narrative about a distressed Indian girl who took her own life by drowning.

6.2. Summary of Key Findings

Richard Wright's Black Boy exhibits an individualistic notion of self and societal restrictions typical of the Southern black experiences in the post-Civil War antebellum period. Written with autobiographical authenticity, Black Boy explores Richard's search for self and identity in a world of severe violence and terror. Black Boy depicts a search for selfhood through the notion of food and writing as a metaphor of free request and individuality. Besides Richard's grappling with himself and his effort to form an individualistic identity, he offers a thorough critique of the Southern society that imprisons and impoverishes its inhabitants – both the whites and the blacks. Wright offers a continuum of representative characters that are manifestations of negative societal power on the individual that culminates with Wright's mother's hopelessness and Richard as a boy and a youth. Richard's narrative closes the text with his escape from the South, a dilemma of self-selection between passage to self-confirmation and belonging to community, of which he had to leave all behind. A longing for substance and connectivity is missing. The independence has been sided with void, impotence, and alienation, a perception that captures him long after escaping. Wright expresses a desire to belong to a group and a society which could provide him with consolation to his anxious individualistic notions. This contradiction leads to an inability to consummate regarding any promise of both individuality and wholeness between Wright's diverging, oppositional desires. One is the wish of a self-full national identity and the other an urge for an individualistic

notion of self, liberated but isolated, where the individual is circumscribed in a sense of non-belonging and no-meaning. Although Black Boy suggests a total suppression of the racial cultural background and crystallization of a new white identity, Wright destroys the hope of any cultural salvage, and in terms of social class, he epitomizes a white-collar black intellectual torn away from the black populace, a black uncle tom not belonging in either race.

Conclusion

Grave tensions arise between self and societal restrictions in Richard Wright's Black Boy. He attempts to liberate himself from external forces. His struggle to uncover his own identity inevitably brings him to a confrontation with the restrictions and constrictions surrounding him. These external obstacles are most visibly manifested in racial prejudice and bigotry, which engender the social restriction and constriction of spiritual life. Other social obstacles include the Southern codes and restrictions imposed on blacks. Richard's attempts at self-identification seem futile at times as they incite more social discrimination and repercussions than self-fulfillment. However, such acts of self-birth are transformative as they continually abandon further restrictions and deeper constrictions. The oscillation between perception and self-recognition results in extensive transformation and ultimately the attainment of self-liberation. This indicates the gradual achievement of autonomy, adaptability, and the ability of self-supportedness as a self. Wright also adopts the structure of cyclical narratives to accentuate the interminable similar conditions of living. The tale of oppression did not cease to exist along with Richard's escape. On the contrary, social discrimination seems to radically transform itself. A severe sense of forfeiture prevails as the perception recognizes the gradual attachments to various covetous bondage. Nonetheless, it is precisely this awareness that breathes hope and reveals the prospect of progressiveness — where there exists a dialectical striving and a sense of bewilderment, there also exists a choice between acceptance and

resistance (Hudson, 2008). The title of Black Boy is not partially indicative of a literal Southern origin: Richard had already expelled himself from the South, but these etiquettes still brand the object of identification. The origin can thus be transformed into scorn, contempt, and antagonism. Wright not only expresses the central processes of identity formation but also cautions against an unqualified bias, disorientation, or xenophobia. Restraint and constriction govern experience and a sense of loss imbues perception. Wright employs simile to effectively foreshadow Richard's impending plight. Written texts cannot rival films in terms of expressiveness and effectiveness regarding the depiction of motion pictures. They can only relay the stream of thoughts through words whose arbitrariness hinders accurate perception. However, filmic depictions of motion frames remain inclusive of everything, even those marginless outside the depicted focus. In Richard's mind, the sense of becoming is potent but confounding as the occurrence is quickly rendered absolute and missed as soon as the mind grasps it . Richard finds no channel for expression and resorting to wordless cinematic streams exceeds limit. This only breeds hypersexed anxiety, as it introduces him to a phantasmagoric fast-paced perception and elongates the previous phenomenal frames. Wright's writings challenge the social duties and status that contemporary society has adopted. Furthermore, his works embraced several cultural norms and transitioned towards inclusion, rendering his society's issues appear as global dilemmas. Between 1908 and 1927, the Southern United States encountered bigotry, brutality, malnutrition, and hardship, among other adversities, as shown in the novel. Throughout his life in the Jim Crow South, Richard Wright seeks his identity. Although Richard's race leads others to make assumptions about him, he successfully challenged these perceptions and established a life in which he maintained complete control. Given the historical deprivation of rights experienced by African Americans, Richard Wright has diligently endeavored to authentically portray their struggles. Despite the black people achieving independence and the Statue of Liberty after decades

of struggle, they continued to endure persistent prejudice and inhumane bigotry. The researcher asserts that African American society encounters several challenges that cannot be resolved without governmental action through the enactment of legislation and constitutional provisions ensuring justice and equality for all societal groups. The enforcement of punitive legislation that holds individuals accountable for engaging in racism or demeaning others.

Recommendations

1. Promote Literary Analysis in Education: Black Boy should be included more widely in educational curricula to foster critical thinking about racism, identity, and social justice among students. 2. Encourage Cross-Cultural Dialogue: Discussions inspired by Wright's narrative can be used to bridge understanding between racial and cultural communities and to confront ongoing racial biases. 3. Support for Marginalized Voices: Scholars and institutions should continue to amplify voices like Wright's that speak truth to power and illuminate the long-standing effects of systemic discrimination. 4. Further Research: Academic researchers should explore parallels between the racial dynamics in Black Boy and those in contemporary society, examining how identity formation is still influenced by race and class. 5. Inclusion in Anti-Racism Initiatives: Excerpts from Black Boy can be used in diversity and sensitivity training to provide a personal, narrative-based perspective on the consequences of racism and exclusion.

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A numerical Treatment for solving quadratic Riccati Differential Equations

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Abstract

In this paper, a numerical technique is introduced to find a numerical solution(NS) of Quadratic Riccati Differential equations(QRDEs) by using Taylor serie's method(TSM).Different kinds of linear and non linear differential equations have been solved utilizing the proposed method with the initial conditions, at any point t_k this technique transformed the QRDEs in to a series. Then it solved by using soft ware-MATLAB.Two different examples have introduced to shown the efficiency and accuracy of the method. The $QRDE_s$ existence and uniqueness are studied.The stability and the upper bound of error are proven.The solutions of the proposed method also compared with those obtained by the Bezier curves method(BCM) and the classical Runge Kutta method of order four (RK4. The results are given by tables and figures of the proposed method outperformed the other methods in terms of accuracy and convergence.

Keywords: Tayler series, Quadratic Riccati Differential equation, Exact solution ,Numerical solution, absolute error.

المعالجة العددية لحل معادلات ريكاتي التفاضلية التربيعية

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الخلاصة
في هذا البحث تم تقديم تقنية عددية لايجاد الحل العددي لمعادلات ريكاتي التفاضلية التربيعية باستخدام طريقة متسلسلة تايلر. انواع مختلفة من المعادلات التفاضلية الخطية وغير الخطية تم حلها باستخدام هذه الطريقة المقترحة مع الشروط الابتدائية عند اي نقطة هذه الطريقة تحول معادلات ريكاتي التفاضلية التربيعية الى متسلسلة ثم تم حلها بأستخدام برنامج الماتلاب تم تقديم مثالين مختلفين لاظهار كفاءة ودقة الطريقة .تمت دراسة الوجود ووحدانية الحل لمعادلات ريكاتي التفاضلية التربيعية. تم اثبات الاستقرارية والحد الاعلى للخطأ. تمت مقارنة حلول الطريقة المقترحة مع تلك التي تم الحصول عليها بواسطة طريقة رنك- كتا من الدرجة الرابعة وطريقة منحنيات بيزير النتائج اعطيت من خلال الجداول والاشكال حيث تفوقت الطريقة المقترحة على الطرق الاخرى من حيث الدقة والتقارب .

1.Introduction

Riccati differential equations(RDEs) are a class of nonlinear differential equations of much importance, and play a significant role in many fields of applied science[1].The RDEs is named after the Italian nobleman Count Jacopo Francesco Riccati(1676-1754)[2].Usually these types of equations are needed to be solved numerically; of course there are many different ways to solve them. Such as; in 2020 the legendre collocation method(LCM)[5],the least-squares approximation and the operational matrices[6].Later in 2021 the variational Iteration method[7],the Fourier Transform and A domian methods[8],the Homotopy perturbation method[9].Recently in 2023 the Cubic B-Spline[10] and in 2024 the fourth-order-Runge-Kutta methods(RK4)[11].All the above methods motivated us to think about the study of the NS by using the proposed method TSM.

This paper begins with the description of the QRDEs, the NS is obtained by using TSM, at any point $t_k$this technique transformed the QRDEs in to a series. Then it solved by using

soft ware-MATLAB. The existence and uniqueness of the QRDE are studied. The upper bound of error and the stability are studied. Finally, two examples are given to solve different problems using the TSM, the results were given by tables and figures which show the efficiency and accuracy of the proposed method.

Description of the problem

Consider the nonlinear RDE as the following form

$$f(t,w)=\frac{dw}{dt}=\alpha_1(t)+\alpha_2(t)w(t)+\alpha_3(t)w^2(t), t_0\le t\le t_f \quad (1)$$

With the initial condition

$$w(t_0)=\alpha_0 \quad (2)$$

Where $\alpha_1(t),\alpha_2(t)$ and $\alpha_3(t)$ are continuous with $\alpha_3(t)\neq 0$,t_0,t_f and α_0 are arbitrary constants, and $w(t)$ is unknown function.

The RDE$_s$ are numerically solved using Taylor series

Consider the first order differentia1 equation(1).Differentiating(1),to obtain

$$\frac{d^2w}{dt^2}=\frac{\partial f}{\partial t}+\frac{\partial f}{\partial w}\frac{dw}{dt'}$$

Which means

$$w''=f_t+f_wf \quad (3)$$

$$w'''=\frac{\partial^2 f}{d^2t}+\frac{2\partial^2 f}{\partial t\partial w}w'+(\frac{\partial f}{\partial w}w')^2 \quad (4)$$

By differentiating this in steps, to get

w^{iv} etc. let $t=t_0$ and $w=0$, the values of w_0',w_0'',w_0''' can be obtained .Hence The TS

$$w_{TS}(t)=w_0+(t-t_0)w_0'+\frac{(t-t_0)^2}{2}w_0''+\frac{(t-t_0)^3}{6}w_0'''+\cdots+ \quad (5)$$

Gives the values of w for every value of t for which (5) converges.

4.The Algorithm for solving(QRDE)

Input :a, b, n ,initial condition, ES.

Output: The numerical solution of the QRDE.

Step1: Subsitute t_0 in $w_{TS}(t)$

Step2: Calculate $w_0, w_0^{'}, w_0^{''}, w_0^{'''}, \dots, w_0^{(n)}$.

Step3: Subsitute Step2 in $w_{TS}(t)$.

Step4: Calculate $t_k = a + k\frac{(b-a)}{n}$ $(k = 0, \dots, n)$.

Step5:Subsitute t_k in $w_{TS}(t)$.

Step6: Calculate the NS of The QRDE by using TSM.

Step7: Calculate absolute error is the comparison between the Exact and the numerical solutions.

Step8:End.

5.Theorem(existence and uniqueness of the QRDE)[14]

Suppose f(t ,w) be defined and continuous for all points (t ,w) in the region D given by $a \le t \le b, -\infty < w < \infty$, where a and b finite, and ∃ a constant σ such that(s.t) ,∀ t, w, w^* s.t (t, w) and (t, w^*) are both in D:

$$\left| f(t,w) - f(t,w^*) \right| \le \sigma \left| w - w^* \right| \quad (6)$$

Then, ∃ a unique solution w(t) of the problem (1), if ξ is any given number,where w(t) is continuous and differentiable for all (t,w) in D.The requirement(6) is called as a "lipschitz condition" and the constant σ as a "lipschitz constant".

6.Convergence of the QRDE

Consider Eq.(1) at the discretized point as :

$$f(t_k, w_k) = \alpha_1(t_k) + \alpha_2(t_k)w(t_k) + \alpha_3(t_k)w^2(t_k), \quad t_0 \le t \le t_f \quad (7)$$

Also, consider the linear first order experiment differential equation

$$w^{'} = \beta w, w(t_0) = w_0$$

Where β is a constant , and has its solution in the form of

$w(t) = w(t_0)e^{(\beta(t-t_0))}$ which at $t = t_0 + kh$

The solution becomes

$$w(t_k) = w(t_0)e^{\beta kh} = w_0(e^{\beta h})^k \quad (8)$$

Let the non-linear QRDE of the form given in Eq.(1) and Eq.(7) written as

$$w' = f(t, w); w(t_0) = w_0 = \alpha_0 \quad (9)$$

The non- linear function Eq.(9) can linearized by expanding the function in TS about the point(t_0, w_0) and truncating it after the first term:

$$w' = f(t_0, w_0) + (t - t_0)\frac{\partial f}{\partial t}(t_0, w_0) + (w - w_0)\frac{\partial f}{\partial w}(t_0, w_0) \quad (10)$$

Using Eq.(7) and by the chain rule differentiation, it yield

$$w' = \alpha_{10} + \alpha_{20}w_0 + \alpha_{20}{w_0}^2 + (t - t_0)\left[\alpha_{10}' + \alpha_{20}'w_0 + \alpha_{20}w_0' + \alpha_{30}'w_0^2 + 2\alpha_{30}w_0w_0' + \alpha_{20}'w_0 + \alpha_{30}w_0' + \alpha_{30}'w_0^2 + 2\alpha_{30}w_0w_0'\right] + w\left[\alpha_{20} + 2\alpha_{30}w_0w_0'\right] - \alpha_{20}w_0 - 2\alpha_{30}w_0w_0'$$

For simplicity let $\alpha_1(t_0) = \alpha_{10}, \alpha_2(t_0) = \alpha_{20}, \alpha_3(t_0) = \alpha_{30}, w(t_0) = w_0, w'(t_0) = w_0'$

And applying Eq.(2) $w(t_0) = w_0 = \alpha_0 =$ constant; So, $w_0' = 0$

$$\rightarrow w' = \alpha_{10}w + \alpha_{20} + \alpha_{30}w_0^2 + (t - t_0)\left[\alpha_{10}' + \alpha_{20}'w_0 + \alpha_{30}'w_0^2\right] \quad (11)$$

This can be rewritten as:

$$w' = \beta w + \Theta$$

Where $\beta = \alpha_{10}, \Theta = \alpha_{20} + \alpha_{30}w_0^2 + (t - t_0)\left[\alpha_{10}' + \alpha_{20}'w_0 + \alpha_{30}'w_0^2\right]$ (12)

Dividing both sides of Eq.(12) by β, to obtain $\frac{w'}{\beta} = w + \frac{\Theta}{\beta}$, if $y = w + \frac{\Theta}{\beta}$, then to get

$$w = y - \frac{\Theta}{\beta} \quad (13)$$

Sub. Eq.(13) in to Eq.(12) gives:

y'
$= \beta y$
Which is called the linear experiment equation for the non-linear Eq.(1)
The solution of this experiment equation, Eq.(15),is:
$y =$
$\gamma e^{\beta t}$
Now, by considering Eq.(5),to have

$$w_{k+1} = w_k + \beta h w_k + \frac{(\beta h)^2}{2} w_k + \frac{(\beta h)^3}{6} w_k + \frac{(\beta h)^4}{24} w_k$$

$$\Rightarrow w_{k+1} = (1 + \beta h + \frac{(\beta h)^2}{2} + \frac{(\beta h)^3}{6} + \frac{(\beta h)^4}{24}) w_k$$

$$\Rightarrow w_{k+1} = E(\beta h) w_k$$

(16)

Where $E(\beta h) = 1 + \beta h + \frac{(\beta h)^2}{2} + \frac{(\beta h)^3}{6} + \frac{(\beta h)^4}{24}$ is TS numerical to $e^{\beta h}$.
If $\beta < 0$, from Eq.(8),the ES $w(t_k)$ decreases at t_k increases. If $\beta > 0$, from Eq.(8),the ES $w(t_k)$ increases with t_k.from Eq.(16) we find the TSM absolutely stable if $\left| E(\beta h) \right| \leq 1$ and relatively stable if $\left| E(\beta h) \right| \leq e^{\beta h}$.

7.Upper bound of error

Here, we give error bound of NS $w_{TS}(t)$
Theorem(4.1): let $w(t)$ and $w_{TS}(t)$ represents NS and the ES of the problem(1),respectively. if $w(t) \in C^r[0,1], r = 0,1, \dots, r+1$ then

$$\left| w(t) - w_{TS}(t) \right| \leq \left| R_n^T(t, t_0) \right| + \left| w_{TS}^T(t) - w(t) \right|$$

When $w_{TS}^T(t)$ exhibits the nth degree TS of w a round the point $t = t_0$ and $R_n^T(t, t_0)$ explain its reminder term.
Proof
Since w is n+1 times derivative, using the TS as a representation, to obtain

$$w(t) = \sum_{k=0}^{n} \frac{(t-t_0)^k}{k!} w^k(t_0) + R_n^T(t, t_0),$$

Where

$$R_n^T(t, t_0) = \frac{(t-t_0)^{n+1}}{(n+1)!} w^{(n+1)}(\delta_t), 0 \leq \delta_t \leq t \leq 1$$

Is the reminder term of the TS of w. let us denotes the nth degree TS of w on the point $t = t_0$ by $w_{TS}^T(t)$. Thus , $w(t) - w_{TS}^T(t) = R_n^T(t, t_0)$. By using it and "triangle inequality" we get

$$\begin{aligned} \left| w(t) - w_{TS}(t) \right| &= \left| w(t) - w_{TS}(t) + w_{TS}^T(t) - w_{TS}^T(t) \right| \\ &\leq \left| w(t) - w_{TS}^T(t) \right| + \left| w_{TS}^T(t) - w_{TS}(t) \right| \\ &= \left| R_n^T(t, t_0) \right| + \left| w_{TS}^T(t) - w_{TS}(t) \right| \end{aligned}$$

Then, an "UBOE''of this method is found for the NS.

8. Illustrative Examples

Example(1):solve the QRDE[12]

$w'(t) =$

$8tw(t) + w^2(t) + 16t^2 -$

$5, (0 \leq t \leq 1), the\ initial\ condition\ is\ w(0) = 1,$ where the ES is w(t)=1-4t.

From TSM

$w'(t) = 8tw(t) + w^2(t) + 16t^2 - 5 \Longrightarrow w'(0) = -4$

$w''(t) = 8tw'(t) + 8w(t) + 2w(t)w'(t) + 32t \Longrightarrow w''(0) = 0$

$w'''(t) = 8tw''(t) + 8w'(t) + 8w'(t) + 2w(t)w''(t) +$

$2w'(t)w'(t) + 32 \Longrightarrow w'''(0) = 0$

$w''''(t) = 8tw'''(t) + 8w''(t) + 8w''(t) + 8w''(t) +$

$2w(t)w'''(t) + 2w'(t)w''(t) + 2w'(t)w''(t) + 2w'(t)w''(t) +$

$2w'(t)w''(t) \Longrightarrow w''''(0) = 0$

TS is

$$w_{TS}(t) = w(0) + tw'(0) + \frac{t^2}{2}w''(0) + \frac{t^3}{6}w'''(0) + \frac{t^4}{24}w''''(0) +$$

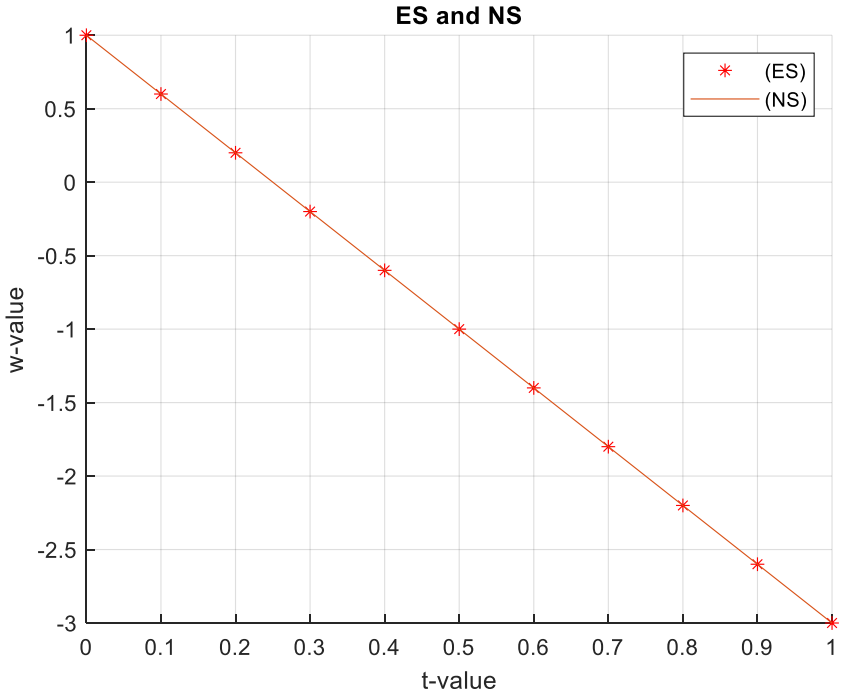
…

$w_{TS}(t) = 1 - 4t$

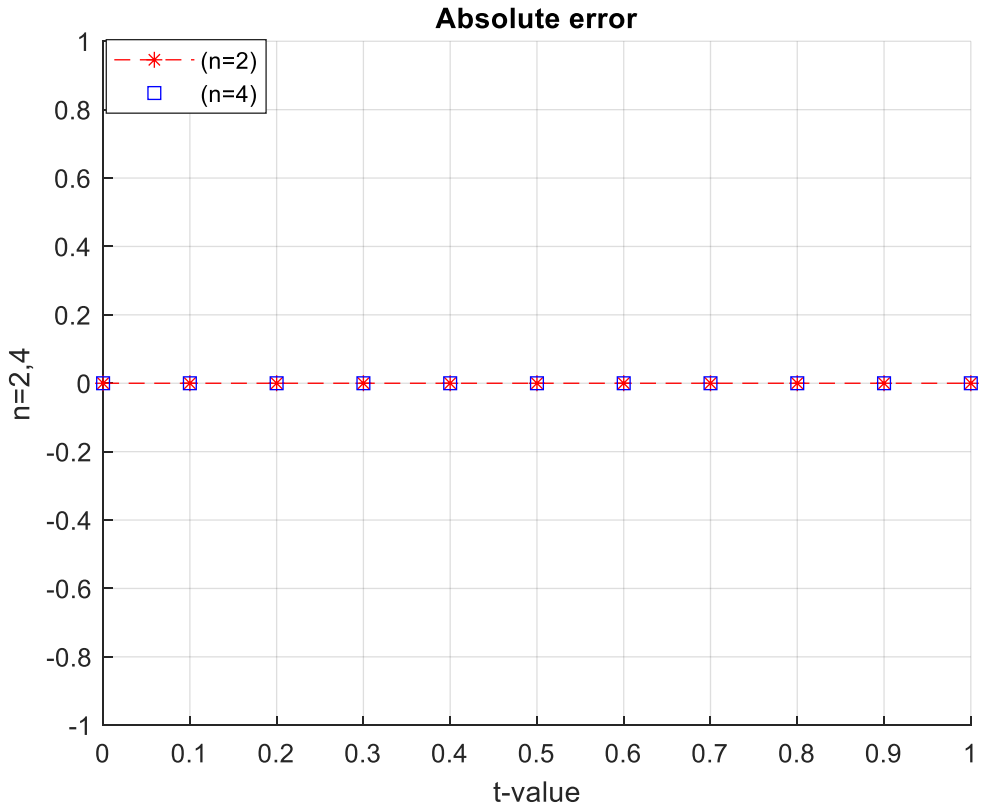
This problem is solved using the TSM for n=4,then the ES(w)and the NS(w_{TS}) at $t_k, k = 0,1,2, \dots, n$. The maximum absolute error in Table(1) is(0.0000)and are shown in figure(1).

Table(1): The ES, NS and absolute error

T	W(ES)	w_{TS}(NS)	$\lvert w - w_{TS} \rvert$
0	1.0000	1.0000	0.0000
0.1	0.6000	0.6000	0.0000
0.2	0.2000	0.2000	0.0000
0.3	-0.2000	-0.2000	0.0000
0.4	-0.6000	-0.6000	0.0000
0.5	-1.0000	-1.0000	0.0000
0.6	-1.4000	-1.4000	0.0000
0.7	-1.8000	-1.8000	0.0000
0.8	-2.2000	-2.2000	0.0000
0.9	-2.6000	-2.6000	0.0000
1	-3.000	-3.000	0.0000



Figure(1): The ES and NS when(n=4)



Figure(2) The absolute error of QRDE for n=2,4

Example(2): solve the QRDE[13]

$w'(t) = -e^{2t} + w + w^2, (0 \le t \le 1), the\ initial\ condition\ is\ w(0) = 1$, with the ES

$w(t) = e^t$.

From TSM

$w'(t) = -e^{2t} + w(t) + w^2(t) \Longrightarrow w'(0) = 1$

$w''(t) = -2e^{2t} + w'(t) + 2w(t)w'(t) \Longrightarrow w''(0) = 1$

$w'''(t) = -4e^{2t} + w''(t) + 2w(t)w''(t) + 2w'(t)w'(t) \Longrightarrow w'''(0) = 1$

$w''''(t) = -8e^{2t} + w'''(t) + 2w(t)w'''(t) + 2w''(t)w'(t) + 2w'(t)w''(t) + 2w'(t)w''(t) \Longrightarrow w''''(0) = 1$

$w'''''(t) = -16e^{2t} + w''''(t) + 2w(t)w''''(t) + 2w'(t)w'''(t) + 2w''(t)w''(t) + 2w'(t)w''(t) + 2w'(t)w'''(t) + 2w''(t)w''(t) + 2w'(t)w'''(t) + 2w''(t)w''(t) \Longrightarrow w'''''(0) = 1$

$w'''''(0) = 1$

$w''''''(0) = 1$

$w''''''(0) = 1$

TS is

$$w_{TS}(t) = w(0) + tw'(0) + \frac{t^2}{2}w''(0) + \frac{t^3}{6}w'''(0) + \frac{t^4}{24}w''''(0) + \frac{t^5}{120}w'''''(0) + \cdots$$

$$w_{TS}(t) = 1 + t + \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24} + \frac{t^5}{120} + \frac{t^6}{720} + \frac{t^7}{5040} + \frac{t^8}{40320} + \cdots$$

This problem is solved using the TSM for n=2,then the ES and the NS at t_k,k=0,1,2,…,n. The maximum absolute error in table(2) is(0.2183)and are shown in figure(2).

Table(2):The ES, NS and absolute error

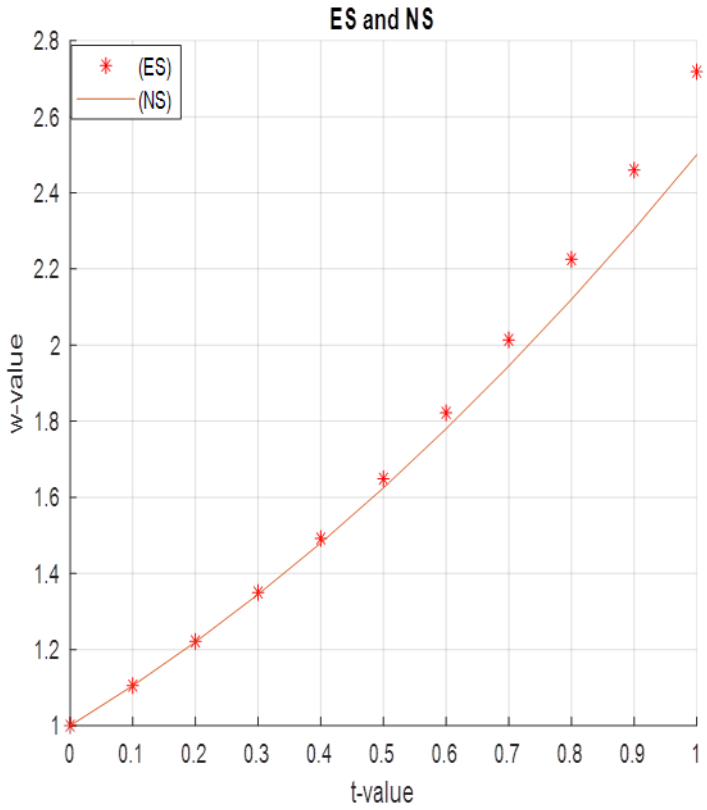
T	w	w_{TS}	$\lvert w - w_{TS} \rvert$ (n=2)
0	**1.0000**	**1.0000**	**0.0000**
0.1	**1.1052**	**1.1050**	**0.0002**
0.2	**1.2214**	**1.2200**	**0.0014**
0.3	**1.3499**	**1.3450**	**0.0049**
0.4	**1.4918**	**1.4800**	**0.0118**
0.5	**1.6487**	**1.6250**	**0.0237**
0.6	**1.8221**	**1.7800**	**0.0421**
0.7	**2.0138**	**1.9450**	**0.0688**
0.8	**2.2255**	**2.1200**	**0.1055**
0.9	**2.4596**	**2.3050**	**0.1546**
1	**2.7183**	**2.5000**	**0.2183**

Table(3):Comparison between the ES ,NS and the maximum absolute error is(0.0099)

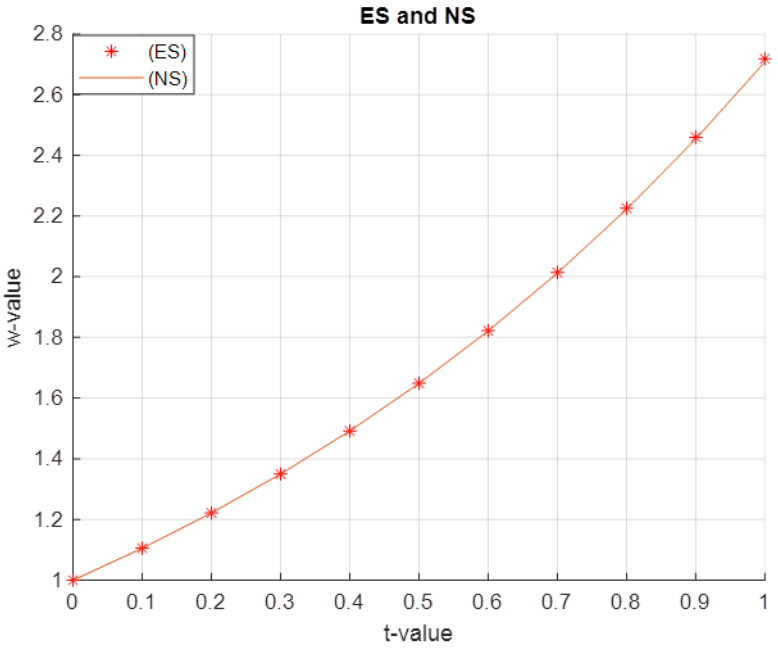
t	w	w_{TS}	$\lvert w - w_{TS} \rvert$ (n=4)
0	**1.0000**	**1.0000**	**0.0000**
0.1	**1.1052**	**1.1052**	**0.0000**
0.2	**1.2214**	**1.2214**	**0.0000**
0.3	**1.3499**	**1.3498**	**0.0000**
0.4	**1.4918**	**1.4917**	**0.0001**
0.5	**1.6487**	**1.6484**	**0.0003**
0.6	**1.8221**	**1.8214**	**0.0007**
0.7	**2.0138**	**2.0122**	**0.0016**
0.8	**2.2255**	**2.2224**	**0.0031**
0.9	**2.4596**	**2.4538**	**0.0058**
1	**2.7183**	**2.7083**	**0.0099**

able(4) Comparison between the ES ,NS and the maximum absolute error is(0.0000)

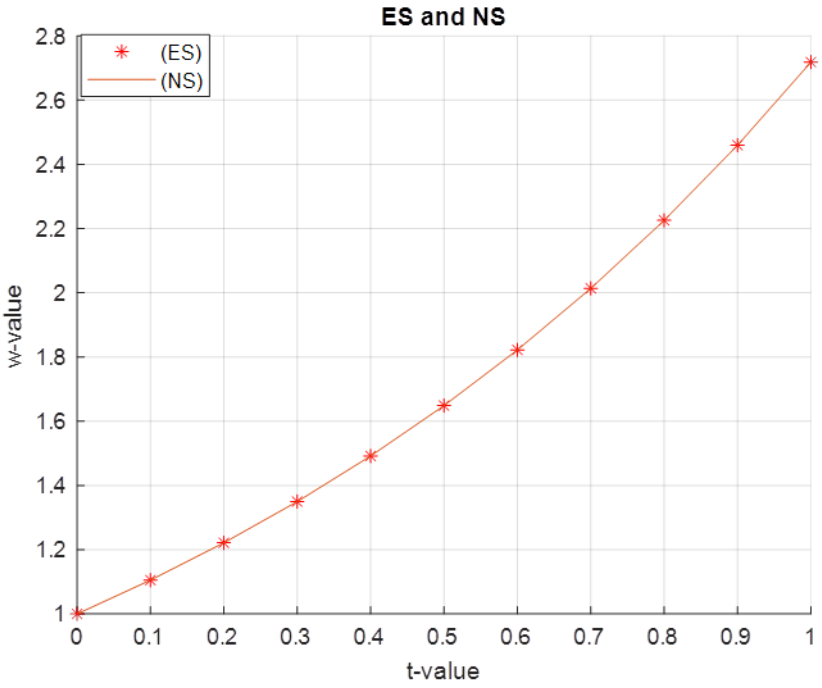
t	w	w_{TS}	$\lvert w - w_{TS} \rvert$ (n=8)
0	1.0000	1.0000	0.0000
0.1	1.1052	1.1052	0.0000
0.2	1.2214	1.2214	0.0000
0.3	1.3499	1.3499	0.0000
0.4	1.4918	1.4918	0.0000
0.5	1.6487	1.6487	0.0000
0.6	1.8221	1.8221	0.0000
0.7	2.0138	2.0138	0.0000
0.8	2.2255	2.2255	0.0000
0.9	2.4596	2.4596	0.0000
1	2.7183	2.7183	0.0000



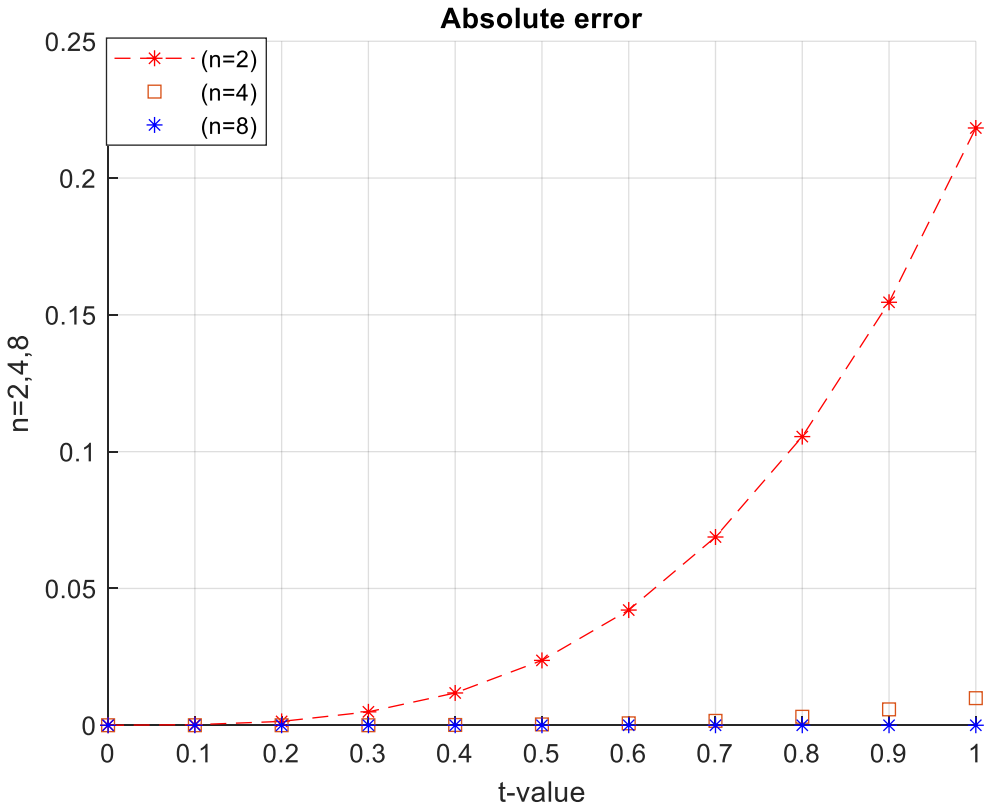
Figure(3):The ES and NS when(n=2)



Figure(4):The ES and NS when(n=4)



Figure(5):The ES and NS when(n=8)



Figure(6) The absolute error of QRDE for n=2,4,8

9.Conclusion

In this search,the TSM is utilized for solving the QRDEs numerically.The stability and the upper bound of the error for this method are studied.Two numerical examples have been applied To prove the efficiency and accuracy of the proposed method .The absolute error comparisons for those of the BCM in [3] and the RK4 in [4] seem to show that the proposed method is better than some of the current methods in terms of error.This method can be extended and applied to solve the system of QRDEs.

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Impact of Artificial Intelligence Technologies on Engineering (Construction) Project Management: An Applied Study on Construction Project Workers in Diyala Governorate

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Abstract:

This research aims to study the impact of artificial intelligence (AI) technologies on the management of engineering (construction) projects through an applied study on construction workers in Diyala Governorate. The study highlights the most prominent AI technologies used in this field, such as smart scheduling models, big data analysis, predictive systems, and risk management, and their role in improving project management performance.

The research adopted a descriptive analytical approach, and data was collected using questionnaires distributed to a sample of workers in the construction sector, in addition to conducting interviews with engineers and field supervisors. The study's results showed that the application of AI technologies in construction projects in Diyala is still in its early stages. However, there is a growing awareness among workers about the importance of these technologies in enhancing work efficiency, reducing costs, and improving execution quality.

The data were analyzed using SPSS version 26, the result show the F-value of favorability reached 37.755, which is higher than the tabular value of 4.412 at two degrees of freedom (1, 48) with a significance level of 0.05. The P-value is 0.000, which is less than 0.05, and the R2 value is 0.553, indicating that artificial intelligence accounts for 43.7% of the changes occurring in

engineering project management. Additionally, the coefficient of determination value reached 0.760, meaning that an increase of one standard deviation in the engineering project management variable will result in a 76% increase in artificial intelligence by one standard deviation.
Key Word: Artificial Intelligence, Engineering Construction Projects, Project Management.

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الخلاصة:
يهدف البحث الى دراسة تأثير تقنيات الذكاء الاصطناعي على ادارة المشاريع الهندسية الانشائية من خلال دراسة تطبيقية على العمال في مجمع راسان السكني في محافظة ديالى .يسلط البحث الضوء على ابرز تقنيات الذكاء الاصطناعي المستخدمة في هذا المجال مثل نماذج الجدولة الذكية ,تحليل البيانات الضخمة ,الانظمة التنبؤية و ادارة المخاطر و دورها في تحسين ادارة المشاريع.
اعتمد البحث على المنهج التحليلي الوصفي ,وتم جمع البيانات باستخدام استبيانات تم توزيعها على عينة من العمال في قطاع البناء ,بالاضافة الى اجراء مقابلات مع المهندسين والمشرفين والميدانيين.اظهرت نتائج الدراسة ان تطبيق تقنيات الذكاء الاصطناعي في مشاريع البناء في محافظة ديالى مازال في مراحله الاولى .ومع ذلك هناك وعي متزايد بين العمال باهمية هذه التقنيات في تعزيز كفاءة العمل ,وتقليل التكاليف ,وتحسين جودة التنفيذ.
تم تحليل هذه البيانات باستخدام برنامج (**SPSS**)الاصدار(**26**) واظهرت النتائج ان قيمة **(F)**الافضلية بلغت **(37.75)**وهي اعلى من القيمة الجدولية (**4.412**)عند درجتين من الحرية **(48.1)**بمستوى دلالة **,(0.05)**وكانت قيمة**(P)**هي(**0.000**) اقل من(**0.05**) بينما بلغت قيمة **R2 (0.553)**مما يشير الى ان الذكاء الاصطناعي يمثل (**43.7%**) من التغيرات الحاصلة في ادارة المشاريع الهندسية . بالاضافة الى ذلك ,بلغت قيمة معامل التحديد(**0.760**), ممايعني انه مع زيادة انحراف معياري واحد في متغير ادارة المشاريع الهندسية سيؤدي ذلك الى زيادة بنسبة(**76%**) في الذكاء الاصطناعي بزيادة انحراف معياري واحد.
الكلمات المفتاحية :الذكاء الاصطناعي، مشاريع البناء، إدارة المشاريع الهندسية .

Introduction:

A construction project is an achievement resulting from a specific effort, bound by a specific period and precise criteria that govern its success. Each construction project has its own unique characteristics and features. Building a school differs from building a hospital in terms of planning, resources, equipment, supplies, and implementation phases. It is important to note here that the completion of a construction project is bound by a specific time period and an appropriate budget is allocated for it. The size of the project is usually measured by the degree of complexity is measured by the number of activities required and the degree of overlap between them. It can also be inferred by listing the entities involved in construction projects and the activities performed by different entities. This study seeks to identify the impact of artificial intelligence on engineering project management in Diyala Governorate, reveal the various factors required for the success of engineering projects, and highlight scientific methods for engineering project management in Diyala Governorate. This study aims to develop methods that help control these projects in a positive and highly effective manner, contributing to achieving the desired goals. At the forefront of modern scientific methods is the adoption of artificial intelligence and its software, based on the application of engineering project management processes. This concept focuses on managing various types of information that can be clearly and explicitly stated.

Large and complex engineering projects require precise coordination and clear planning to ensure success within the specified time and budget. With the advancements in science and technology, it has become essential to use and apply advanced and modern techniques to improve and ensure the success of managing such projects. Among these technologies is artificial intelligence, which is considered one of the latest innovations and most significant advancements contributing to a revolution in many fields, including the engineering sector. This technology focuses on simulating the organized human decision-making process based on a set of rules and specialized

knowledge. Therefore, it becomes an effective tool in enhancing the accuracy of complex decisions, finding smart solutions in real time, and achieving the best results in engineering projects.

This study aims to explore the importance of using artificial intelligence for expert systems in managing engineering projects and its impact on improving processes and decision-making within engineering environments. Consequently, it seeks to bridge the gap between theoretical capabilities and practical implementation.

Research Problem:

What is the impact of using artificial intelligence technology on engineering project management in Diyala Governorate?

Research Hypotheses:

First Main Hypothesis: There is a correlation between the use of artificial intelligence technology and engineering project management.

Second Main Hypothesis: There is a statistically significant effect between the use of artificial intelligence technology and engineering project management.

Significance of the Study:

The importance of the study stems from the importance of the topic and its focus on the role of artificial intelligence in engineering project management to expedite the completion of construction projects. These challenges are often addressed in terms of time, cost, quality, and other conditions for the success of construction projects in the governorate. Since the prosperity and development of infrastructure in Iraq's governorates, the government has been striving to invest in and develop construction projects to serve the interests of the state and the individual, especially after the implementation of a series of engineering and architectural projects in 2024 and 2025. Therefore, it is working to incorporate and implement all that is modern and contemporary to help advance all its achievements. Contribution can also be made through the results and

recommendations that will lead to improved performance in construction companies by identifying the main obstacles facing engineering project management, identifying their causes, and working to address them.

Study Objectives:

To study and analyze the obstacles facing engineering project management in various regions of the governorate that prevents projects from achieving their objectives.

To identify the impact of applying artificial intelligence technology in engineering project management.

To identify areas of deficiency in the completion of engineering projects and determine the causes of these shortcomings. - Identify the role of engineering projects in economic and social development in the governorate, given the recent developments in engineering projects.

Study Methodology:

The study relies on a descriptive-analytical approach, as well as a deductive approach, examining the impact of artificial intelligence technology on engineering project management from the perspective of construction project workers in Diyala Governorate. The practical part of the study was carried out on a random sample of workers. The research also aims to highlight the various advantages of the statistical findings and connect them to the different factors and influences that contributed to the current outcomes. The SPSS statistical software was used to analyze and process the data and to test the validity of the hypotheses.

Study Limits:

- Spatial Limits: Construction project workshops in Diyala Governorate were selected.
- Temporal Limits: The study period was between February 1, 2025, and April 1, 2025.
- Human Limits: A sample of engineering project workers.

The Theoretical Aspect

The Concept of Artificial Intelligence

Human cognition is a complex class of phenomena that artificial intelligence systems interact with in two distinct ways. Proponents of what is known as strong AI are interested in building systems that behave at a level indistinguishable from humans. Success in strong AI will lead to the production of computer minds located in independent physical objects, such as robots, or perhaps in virtual worlds, such as the information space created by the Internet.[1]

An alternative approach to strong AI is to examine human cognition and explore ways to support them in difficult or complex situations. For example, a fighter pilot might need the assistance of intelligent systems to help navigate a highly complex aircraft that they cannot operate alone. These simple methods are not intended to be autonomous, but rather a form of cognitive enhancement to support humans in multiple tasks. In the field of medicine, artificial intelligence systems are used to support healthcare workers in performing their duties, specifically in tasks that rely on data and knowledge. An AI system might operate within an electronic medical system, for example, and alert a clinician when it detects indicators that contradict the treatment plan. It might also alert a physician when patterns are detected in the data that indicate significant changes in a patient's condition.[2][3]

Human experts possess a vast amount of specialized knowledge in their fields of expertise, so expert systems are typically based on knowledge bases that contain a vast number of databases containing this knowledge. Expert systems emerged as a branch of artificial intelligence. The beginning of the emergence of this field dates back to the fifties of the twentieth century, when a group of scientists adopted a new approach to producing intelligent machines based on recent discoveries in neuroscience, using new mathematical theories of information and relying on the invention of devices built on the essence of mathematical logic. The first recorded event in the field of artificial intelligence was the publication of a scientific paper

"Computing Machinery and Intelligence" by the British mathematician Alan Turing, in which he invented a test that, if passed, classifies the machine as intelligent. This test consists of questions asked by a person known as the judge and directed to another person and a computer simultaneously. If the judge is unable to distinguish between the person and the machine, then the machine passes the intelligence test and is described as an intelligent machine.[4][5]

There are several perspectives on defining artificial intelligence. Some of these perspectives rely on important aspects of the classification and definition of intelligence, such as rationality, thinking, actions, decision-making, and others. These are linked based on a cognitive perspective. Artificial intelligence can be defined as intelligence manifested in a non-natural, artificial entity (human-made). Artificial intelligence is a branch of informatics that studies the development of intelligent algorithms and technologies for application in computers and robots, enabling them to behave intelligently in performing tasks or solving problems. When artificial intelligence is integrated into the work environment, interacts with it, and learns from it, it is known as an intelligent agent. Artificial intelligence is also viewed as the study of intellectual abilities through the use of accounting models, which focuses on how to simulate human thinking. The central goal of the artificial intelligence model is that both the human and the model make predictions about a particular phenomenon through signs, signals, or certain clues. A more comprehensive definition can be defined as the ability to think and make good decisions using a non-human mind.[12][13][15]

Engineering Project Management

The process of planning, organizing, directing, and controlling resources (human, material, and financial) to achieve the objectives of a specific engineering project within a specific timeframe, budget, and with high quality. This management encompasses a set of skills, tools, and standards to ensure the success of complex engineering projects, such as bridge

construction, building construction, infrastructure development, or industrial system design.[7][8]

Project management has a long-standing historical foundation and has progressively developed throughout the centuries. Its earliest manifestations can be observed in ancient times, exemplified by large-scale constructions like the Egyptian pyramids and the Great Wall of China. A significant advancement in modern project management was the introduction of the Gantt Chart by Henry L. Gantt in 1917 (Pacagnella and da Silva 2023). During the 1950s and 1960s, influential thinkers such as Peter Drucker and Frederick Taylor contributed to shaping theories focused on organizing and managing production processes (Winkler-Schwartz et al. 2019) .[9][11].[14].

The Importance of Engineering Project Management [16][19]

1. Ensuring on-time delivery: Avoiding delays that can increase costs.
2. Controlling costs: Preventing budget overruns through careful financial planning.
3. Achieving the required quality: Adhering to technical specifications and standards.
4. Risk management: Identifying potential threats and developing mitigation plans.
5. Improving communication between teams: Coordinating work between engineers, contractors, and clients.

Previous study

In 2017, Luger G, described the complexity of artificial intelligence in a way that no theory can fully define it. Therefore, researchers have created a hierarchical framework consisting of theories, networks, and algorithms that have helped adapt and interact with various environments that require the use of any form of intelligent and advanced activities.

In 2014, a study by Aziz and other researchers highlighted that planning, scheduling, and controlling large building projects

require significant methods and procedures, which form the foundation of the project life cycle. The study demonstrated the benefits of using the Critical Path Method (CPM) for scheduling and optimizing massive projects, as well as the Genetic Algorithm (GA). The study aimed to provide support for planners of large construction projects to reduce project duration and costs while improving quality under the name (SCPMS).

In 2016, this study outlined the principles followed in managing portfolios and programs within an organization, which involve translating the business strategy into groups of activities that deliver the desired benefits and outcomes that individual efforts cannot provide, in terms of project cost estimates and pricing. The organization's strategic vision is achieved through controlling program management in terms of program initiation, managing program risks, managing benefits, and controlling the program through the benefits achieved and the techniques used for managing programs and projects.

. In 2018, Jeams conducted a study showing that the capabilities developed by artificial intelligence have enabled businesses to reach higher levels, improving both the value and efficiency of operations, as well as execution speed. This has attracted widespread interest and engagement due to the rapid advancement and development of tools and software.

A technical and field study was conducted. From a technical perspective, artificial intelligence has become a leader in two scientific fields: behavioral and neural sciences, and informatics, which includes algorithms in all their theoretical and practical applications. This theory enabled prediction and decision-making that adapts to the environment, replacing human decision-making.

The self-evolution, automatic behavior, learning, and the depiction of the horizon of smart technology are features of artificial intelligence that have granted machines complete freedom in decision-making.

In 2021, the study clarified that the effectiveness and success of artificial intelligence technology have created an exceptional digital environment for researching, processing, and storing

information across various fields, such as industry, transportation systems, communications, and others.

After the advancements in expert systems, they have become an effective tool for developing distance learning, enabling the potential for virtual education in the future, especially if future data is considered. This makes the coming stages a phase of convergence and integration between the biological and technological realms.

In 2022, this study clarified the impact of artificial intelligence technologies in enhancing and improving the quality of governance and the potential for linking these technologies, based on information and communication technology, with political science.

In 2022, this study identified the importance and role of artificial intelligence in achieving the Saudi Arabia Vision 2030 development goals, and clarified the impact of artificial intelligence on supporting sustainable development from economic, social, and environmental perspectives in both the private and public sectors. This was done through applying a descriptive analysis approach to describe and interpret phenomena by utilizing historical sources, information, and statistical data.

In 2023, due to the widespread use of Artificial Intelligence (AI) and Machine Learning (ML) in various fields such as business, it has become possible to transform traditional work methods and support project managers in their daily tasks. This means that projects can be managed through AI applications, allowing project managers to establish foundations for work that contribute to improving and developing projects. It is crucial to increase awareness and knowledge about how to automate processes between stakeholders and organizations. As a result, risks can be reduced, excessive costs can be avoided, and employee efficiency can be enhanced, leading to greater satisfaction.

Research Sample and Data Collection Method:

The researchers used a simple random sampling method to distribute the questionnaires to a sample of workers at the Rasan Housing Complex in Diyala Governorate, assuming a homogeneous population. An appropriate sample was then drawn, with 80 questionnaires distributed to a sample of workers at the complex. 75 valid questionnaires were returned for analysis, representing a response rate of 90%.

Statistical Indicators:

The researchers conducted their statistical analysis using data gathered through a five-point Likert scale. They applied key statistical measures via the SPSS software package (version 26), ensuring consistency with the study's hypotheses and specific research questions. The primary indicators utilized include the following:

A. Frequencies and percentages are used to identify the number and proportion of respondents within the research sample.

B. The weighted arithmetic mean is used to assess the level of agreement of the research sample with the questionnaire items

C- Standard Deviation: Used to measure the extent of variation or dispersion in the research sample's responses concerning the level of agreement.

C-Pearson Correlation Coefficient: It is used to measure the strength and direction of the association between research variables, indicating whether the relationship is direct (positive) or inverse (negative).

C- F-Test:It is used to determine whether the independent variables in the research have an effect on the dependent variable.

H-Regression analysis is used to assess the degree to which the independent variable affects the dependent variable.

Description of the Research Sample:

The research sample included a group of individuals surveyed in the Rasan complex in Diyala Governorate. Table (1) shows the characteristics of the individuals in terms of gender, degree, experience, and job title.

Table No. (1) Frequencies and percentages of demographic variables of the research

Information	Category	Number	Percentage
Gender	Male	55	73.0
	Female	20	27.0
Total		75	100.0
Education	Intermediate or lower	22	29.0
	Preparatory education	18	24.3
	Bachelor's degree	35	46.7
Total		75	100.0
Experience	less than 5 years	7	9.0
	6-10 Years	11	15.0
	11- 15 Years	27	36.0
	16 years and above	30	40.0
Total		75	100.0
Job	Lawyer	9	12,00
	Accountant	4	5,00
	Engineer	16	21,00
	Accounts Manager	8	11,00
	Driver	9	12,00
	Two-Craft	17	23,00
	Department Manager	2	3,00
	Service Worker	10	13,00
Total		75	100.0

Source: Prepared by the researcher based on calculator results.

From Table (1), the results are as follows

• The gender variable showed that the number of males was 55, representing 73% of the total sample, which is higher than the percentage of females.

• The degree variable showed that those with a bachelor's degree had a value of 35, representing 46.7% of the total sample, which is higher than other degree holders.
• The experience variable showed that employees with 16 years of experience or more had a numerical value of 30, representing 40% of the total sample, which is higher than the number of experienced employees.
• The job variable showed that the two letters had a value of 17, representing 23% of the total sample, which is higher than the other occupations.

Description and diagnosis of research variables:

This section presents the description and analysis of the main research variables: artificial intelligence, considered the independent variable, and engineering project management, considered the dependent variable. To accomplish this, appropriate statistical analyses were employed to calculate the arithmetic means and standard deviations of the participants' responses concerning both artificial intelligence and engineering project management. Table (2) displays the description and analysis of the artificial intelligence variable.

Table No. (2) below describes the research variables related to artificial intelligence.

Variables	Strongly agree		Agree		Neutral		Disagree		Strongly disagree		Mean	Standard deviation
	Nom	%	Nom	%	Nom	%	Nom	%	Nom	%		
X1	15	20	30	40	27	36	8	11	0	0	3.9800	0.98242
X2	7	9	26	35	18	24	14	18	0	0	3.5400	0.95384
X3	8	11	20	27	15	30	21	28	0	0	3.5900	0.75928
X4	3	4	28	37	8	16	6	12	4	8	3.3800	1.11098
X5	17	23	24	32	10	20	6	12	0	0	3.7800	0.97646
X6	19	25	25	33	9	18	4	8	0	0	3.8200	0.80026
General average											3.8800	0.92660

Source: Prepared by researchers based on calculator results

The results presented in Table (2) show that artificial intelligence obtained an overall mean score of 3.88 with a standard deviation of 0.92660, indicating a high degree of consistency in the participants' responses. At the item level,

item (1) in this domain (X1) exhibited the highest level of response consistency, with a mean score of 3.98 and a standard deviation of 0.98242. The response trend for this item was "agree," which aligns with the overall trend for the artificial intelligence variable, also categorized as "agree." Table (3) displays the means and standard deviations of the participants' responses related to employee performance.

Table No. (3) Description of Engineering Project Management

Variables	Strongly agree		Agree		Neutral		Disagree		Strongly disagree		Mean	Standard deviation
	Nom	%	Nom	%	Nom	%	Nom	%	Nom	%		
X1	27	36	25	50	23	30	5	6	0	0	4.4500	0.60238
X2	1	1	29	58	7	14	21	30	0	0	3.7800	0.86402
X3	2	3	26	52	9	18	1	2	0	0	4.4900	0.73983
X4	20	27	27	54	14	28	2	4	0	0	4.7800	0.75551
X5	30	40	30	60	10	20	3	6	1	2	3.7400	0.82833
X6	11	15	25	50	13	26	2	4	0	0	3.8600	0.78272
General average											3.8256	0.89125

Source: Prepared by researchers based on calculator results

The results in Table No. (3) show that the Engineering Project Management variable achieved an overall mean score of 3.8256 with a standard deviation of 0.89215, indicating consistency in the sample responses regarding the average value. At the item level, Item No. (4) under this variable (X4) demonstrated the highest consistency, with a mean of 4.7800 and a standard deviation of 0.75551. The response trend for this item was "Agree," and the overall trend for the Engineering Project Management variable was also "Agree."

Hypothesis Testing:

The analysis of the correlation between artificial intelligence and engineering project management at the residential complex site under study serves as a test of the first main hypothesis, which posits a significant relationship between the two. The data presented in Table (4) demonstrate a strong correlation, with a coefficient of (**0.680) and a significance value (sig.) of 0.001—well below the 0.01 threshold, confirming the result with 99% confidence. These findings highlight the strength and statistical significance of the relationship, leading to the

rejection of the null hypothesis and the acceptance of the alternative hypothesis.

Table (4) represents the correlation between artificial intelligence and engineering project management.

Correlations		
		Engineering Project Management.
Artificial Intelligence	**Pearson Correlation**	****0.680**
	Sig. (2-tailed)	**0.000**
	N	**75**
****. Correlation is significant at the 0.01 level (2-tailed).**		

Source: Prepared by the researchers based on the results of the ready-made SPSS software, N = sample size.

Analysis of the impact of the relationship between artificial intelligence and engineering project management at the construction site of the residential complex under study :

The content of this analysis tests the second main research hypothesis, which posits a significant impact between artificial intelligence and engineering project management. Table (5) demonstrates that a significant impact exists between artificial intelligence and engineering project management, as the F-value of favorability reached 37.755, which is higher than the tabular value of 4.412 at two degrees of freedom (1, 48) with a significance level of 0.05. The P-value is 0.000, which is less than 0.05, and the R2 value is 0.553, indicating that artificial intelligence accounts for 43.7% of the changes occurring in engineering project management. Additionally, the coefficient of determination value reached 0.760, meaning that an increase of one standard deviation in the engineering project management variable will result in a 76% increase in artificial intelligence by one standard deviation. This implies the rejection of the null hypothesis and acceptance of the alternative hypothesis, confirming that there is an impact between artificial intelligence and engineering project management. In other words, engineering project management in engineering projects

in Diyala Governorate, under study, relies on artificial intelligence.

Table (5) Impact between artificial intelligence and engineering project management

Independent variable / Dependent Variable	Engineering Project Management		R^2	F	
	B_o	B_1		Calculation	Tabular
Artificial intelligence	0.660	0.760 (5.624)	0.553	37.755	4.412

Source: Prepared by the researchers based on the results of the electronic calculator (spss). The calculated t value indicates df (1,48) N=50 P < 0.05.

Research Conclusions

These conclusions were reached through a discussion of the study results, which included a set of key points through which the impact of artificial intelligence technology in engineering project management can be understood. The most prominent of these are:

- The acceptance and awareness of the use of artificial intelligence technology in engineering project management among employees who expressed their opinions on the concept of artificial intelligence.
- Increased knowledge and preparedness to use artificial intelligence technology in engineering project management among engineering project workers in Diyala Governorate.
- Developing training courses and workshops specifically for the use of artificial intelligence technologies in engineering project management, which will enhance knowledge in this field.
- Reducing engineering plan defects and delays in project completion, further improving project performance, and avoiding errors and delays in completion.

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Integrating Sustainability into Mechanical Systems' Life Cycle Assessment Using Mathematical Optimization Techniques

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Abstract:
This study enhances the Life Cycle Assessment (LCA) of mechanical systems by integrating sustainability principles and applying mathematical optimization techniques. Advanced mathematical models were employed to analyze data and evaluate environmental impacts across key lifecycle stages, including raw material extraction, manufacturing, operation, and end-of-life disposal. The results demonstrate significant improvements in assessment accuracy, identifying critical optimization points to reduce carbon footprint and energy consumption. Previously unaccounted environmental effects, such as toxic emissions from motor insulation materials, were also revealed, underscoring the need for comprehensive LCA methodologies.
Keywords: Life Cycle Assessment, Mathematical Optimization, Sustainability, Carbon Footprint, Energy Efficiency

إدماج الاستدامة في تقييم دورة حياة الأنظمة الميكانيكية باستخدام تقنيات التحسين الرياضي

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كلية المقداد للتربية / جامعة ديالى

الملخص:
تعزز هذه الدراسة تقييم دورة الحياة (LCA) للأنظمة الميكانيكية من خلال دمج مبادئ الاستدامة وتطبيق تقنيات التحسين الرياضي. تم استخدام نماذج رياضية متقدمة لتحليل البيانات وتقييم الآثار البيئية عبر مراحل دورة الحياة الرئيسية، بما في ذلك استخراج المواد الخام، التصنيع، التشغيل، والتخلص النهائي. أظهرت النتائج

تحسناً كبيراً في دقة التقييم، مع تحديد نقاط تحسين حرجة لتقليل البصمة الكربونية واستهلاك الطاقة. كما كشفت عن تأثيرات بيئية لم تُدرج سابقاً، مثل الانبعاثات السامة من مواد عزل المحركات، مما يؤكد أهمية منهجيات تقييم دورة الحياة الشاملة.
الكلمات المفتاحية :تقييم دورة الحياة، التحسين الرياضي، الاستدامة، البصمة الكربونية، كفاءة الطاقة

1. Introduction

computer-aided process modeling simulation can be useful for retrieving this type of data. Afterwards, for every mass or energy flow input or output, comprehensive pollutant or stressor level inventories are retrieved from a standard life cycle inventory database, like Ecoinvent. A comprehensive life cycle characterization in an impact category is obtained by applying the LCIC to specific pollutant or stressor inventories and then aggregating the results [1]. Life cycle inventory data extraction is the most resource-intensive component of an LCSA/LCA project. The scientific-engineering basis of the computer-aided process modeling simulation and the LCSA effect characterizations of polluting ants can be computer-programmed into a digital output that does not now exist. As such, this paper's primary objective is to demonstrate these computational mathematical capabilities through an innovative open-source digital output hosted on the web [2][3]. Using life cycle approaches will help companies evaluate how well their products and operations support sustainable development across the complete lifetime [4]. Among these, LCA has experienced great demand recently to support sustainability initiatives in many other sectors, beyond conventional manufacturing. It is quite important in disciplines such architectural engineering, management, and environmental management in assessing and enhancing sustainable practices. This is especially relevant in the building sector, where the environmental effect of recently developed bio-based materials [5-11] has been decided upon. The term "life cycle costing" refers to a method of calculating the whole monetary outlay for an item from its inception to its eventual disposal [12]. Several life cycle costing (LCC) models have been proposed throughout the years, but only two

environmental (eLCC) and social (sLCC)—have gained substantial traction in the academic community .EMergy Accounting is a thermodynamically-based systems-oriented approach to process evaluation that takes environmental impacts into account [13]. The field of lean management is where Value Stream Mapping was first introduced. It seeks to identify and remove manufacturing process waste in a way that small groups or enterprises can implement effectively and practically [14]. Wasted time and inventory were initially seen as indicators of inefficient production systems in the original economic definition of waste. More and more people are starting to realize the powerful synergies between green and lean manufacturing, thus they updated Value Stream Mapping to include more environmental (waste) indicators . Researchers have also shown that it is essential to combine several approaches when evaluating sustainability procedures. As a result, modern businesses are putting a lot of energy into perfecting their sustainability assessment techniques, particularly by integrating life cycle and quantitative approaches to make better decisions. Therefore, in order to fully grasp this merging of approaches, this study uses a systematic review. The systematic literature review gives a more accurate picture of the connection between life cycle and quantitative methodologies, even though bibliometric tools are useful for understanding publishing patterns. Numerous studies have investigated the application of these methods in different settings, such as product design, supply chain management, waste handling, evaluation of sustainable growth, and literature reviews [15] Some of the possible advantages of using such methodologies are better decision-making, more transparency, and more comprehensive sustainability evaluations, as discussed in these studies.In order to do this, this literature study will primarily focus on researching the current literature on the topic of using life cycle based approaches and quantitative methods together for decision-making. Life cycle based methodologies have been extensively used to assess environmental consequences in many different industries. However, it is important to look at how

these methods may be integrated with quantitative decision-making tools, especially in new areas. In order to fill in the gaps, this study finds ways to make these methodologies work better for real-world decision-making and advocates for such solutions [17] . To create more reliable sustainable performance indexes, for example, we propose new approaches that combine LCA findings with FST and DEA. Improving product quality while decreasing resource consumption and environmental effect may be achieved via the application of this pragmatic concept to complex industries like construction and manufacturing. In order to promote sustainable practices across different industries, our research broadens the use of sustainability assessment methodologies and provides a better knowledge of the possible challenges associated with their implementation [18]. Furthermore, there has been a lack of investigation into the use of statistical tools like Analysis of Variance (ANOVA) in sustainability evaluations; our research introduces new ways to include LCA into these processes. These developments allow for more accurate and practical assessments of social and environmental repercussions, which in turn enable stakeholders to make well-informed choices that are in line with

2.0 Methodology

2.1 Inappropriate ISO Application in LCA of a Mechanical System

In this paper, we investigate a real-world scenario involving a modest mechanical engineering company trying to undertake a Life Cycle Analysis (LCA) on an industrial centrifugal pump system. The producer claimed to have followed ISO 14040/14044's guidelines in order to market the pump as being ecologically benign. Still, a third-party review turned up a notable number of LCA process execution issues.

2.2 Procedure of the life cycle assessment based on the international standard

An industrial centrifugal pump system is the subject of this study, which investigates a situation that occurs in the real world and involves a small mechanical engineering company doing a Life Cycle Analysis (LCA). In order to sell the pump as being good to the environment, the business stated that it had adhered to the guidelines of ISO 14040/14044. In spite of this, an independent evaluation indicated an astonishingly high number of errors in the execution of the LCA approach.

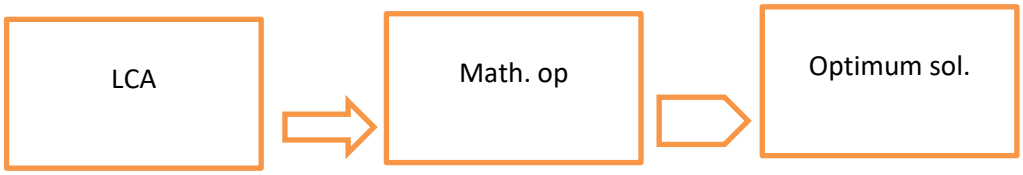

Figure1. Procedure of mathematical optimization

3.3 Multi-objective methods

Python implementation of multi-objective optimization utilizing NSGA-II (Non-dominated Sorting Genetic Algorithm II) under DEAP library. One of the earliest such EAs was the non dominated sorting genetic algorithm (NSGA) .The primary objections to the NSGA strategy over years have been as follows. Non dominated sorting has high computational complexity: With a computing complexity of (where number of targets is the population size), the commonly utilized non dominated sorting method has For sizable populations, this renders NSGA computationally costly. The intricacy of the non dominated sorting process in every generation results in this great complexity.

```
import random
from deap import base, creator, tools, algorithms
# Create the problem (minimize GWP and CED)
creator.create("FitnessMin", base.Fitness, weights=(-1.0, -
1.0))  # Both objectives to minimize
creator.create("Individual", list, fitness=creator.FitnessMin)
```

```
toolbox = base.Toolbox()
# Each individual has 3 variables: [material_type,
motor_efficiency, usage_pattern]
# These are abstracted as real numbers (later interpreted as
categorical choices)
toolbox.register("attr_float", random.random)
toolbox.register("individual", tools.initRepeat,
creator.Individual, toolbox.attr_float, n=3)
toolbox.register("population", tools.initRepeat, list,
toolbox.individual)
# Objective function
def evaluate(individual):
    material, motor_eff, usage = individual
    # Simulate decoding categorical choices (simplified)
    if material < 0.33:
        gwp_material = 2500  # steel
        rec = 0.40
    elif material < 0.66:
        gwp_material = 1700  # aluminum
        rec = 0.58
    else:
        gwp_material = 1000  # recycled aluminum
        rec = 0.65

    if motor_eff < 0.5:
        eff_class = "IE2"
        energy_use = 100000
    else:
        eff_class = "IE4"
        energy_use = 85000

    usage_factor = 1.0 + (0.5 * usage)  # Higher usage = more
impact

    # Calculate objectives
    gwp_total = gwp_material * usage_factor
    ced_total = energy_use * usage_factor
```

```
    return gwp_total, ced_total

toolbox.register("evaluate", evaluate)
toolbox.register("mate", tools.cxSimulatedBinaryBounded,
low=0.0, up=1.0, eta=20.0)
toolbox.register("mutate", tools.mutPolynomialBounded,
low=0.0, up=1.0, eta=20.0, indpb=1.0/3)
toolbox.register("select", tools.selNSGA2)

# Main
def main():
    pop = toolbox.population(n=100)
    hof = tools.ParetoFront()
    stats = tools.Statistics(lambda ind: ind.fitness.values)
    stats.register("avg", lambda x: tuple(map(lambda y:
sum(y)/len(y), zip(*x))))
    stats.register("min", lambda x: tuple(map(min, zip(*x))))
    stats.register("max", lambda x: tuple(map(max, zip(*x))))

    algorithms.eaMuPlusLambda(pop, toolbox, mu=100,
lambda_=200, cxpb=0.7, mutpb=0.3,
                        ngen=50, stats=stats, halloffame=hof,
verbose=True)

    print("\nPareto-optimal solutions:")
    for ind in hof:
        print(f"Design: {ind}, Objectives (GWP, CED):
{ind.fitness.values}")

if __name__ == "__main__":
    main()
```

4. Results and Discussion

4.1 Results of Life Cycle Assessment (LCA)

Several notable alterations were noted following the original Life Cycle Assessment (LCA) being corrected: From the

previously stated 7,100 kg CO_2-eq to 10,450 kg CO_2-eq when the manufacturing step was fully included, Global Warming Potential (GWP) rose. Furthermore, energy consumption throughout the lifetime of the product increased from 85,000 MJ to 122,000 MJ; the emissions from motor insulation chemicals were discovered to be significant and previously unevaluated human toxicity potential was determined to be considerable. These revisions exposed that the original LCA underreported consequences by more than 30%, mostly because to the absence of important life cycle stages and the application of simplified assumptions.

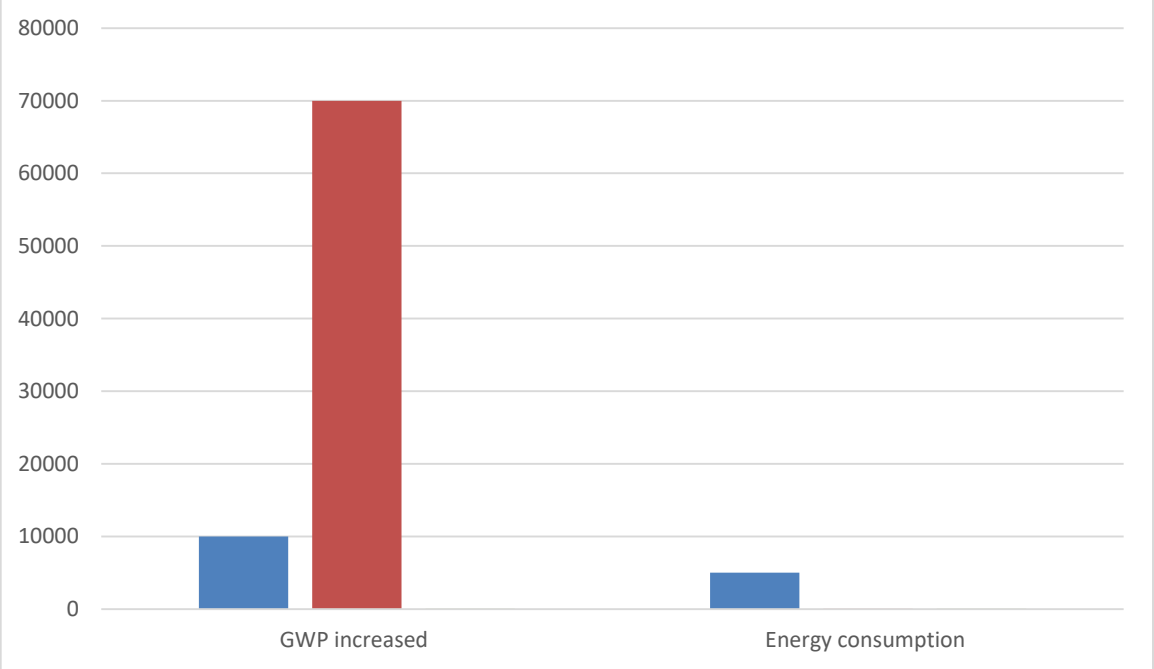

Figure 2. Results of Life Cycle Assessment (LCA)

4.2 Optimization Outcomes

Notable changes were observed once the initial Life Cycle Assessment (LCA) was corrected: Global Warming Potential (GWP) increased from the already mentioned 7,101 kg CO_2-eq to 10,450 kg CO_2-eq when the manufacturing process was completely included. Moreover, energy consumption throughout the lifespan of the product rose from 85,000 MJ to 122,000 MJ; the emissions from motor insulation chemicals were found to be notable and previously unevaluated human toxicity potential

was calculated to be very high. These changes revealed that, largely due to the omission of significant life cycle stages and the use of simplified assumptions, the original LCA underreported impacts by more than 30%.

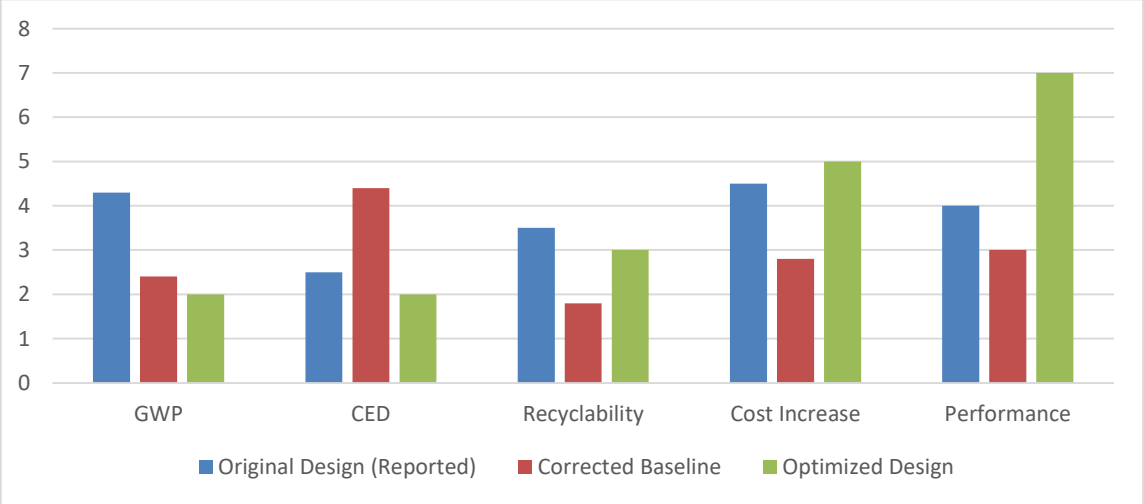

Figure 3. Optimization Outcomes

4.0 Conclusion

This work aims to study the inclusion of sustainability into mechanical system design by means of mathematical optimization and Life Cycle Assessment (LCA). This paper aims to give a case study of an industrial pump system. The case study shows how deficient initial life cycle assessment estimations resulting from improper system constraints and old data resulted in an underestimating of the environmental implications. Mathematical optimization techniques were used in order to reduce the Global Warming Potential (GWP) and the Cumulative Energy Demand (CED) after changes to the life cycle assessment (LCA) in line with ISO 14040/14044. The best design reduced the risk of global warming as well as the energy consumption when cost and performance constraints were taken under account. The results indicate that in order to drive the design of mechanical engineering products that are less detrimental to the environment, a thorough life cycle assessment

(LCA) and investigation of the possibilities of optimization are absolutely required.

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Artificial Intelligence and the Future of Humanity: Towards Sustainable Development Based on Responsible Innovation and Advanced Technology

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Abstract

This research aims to examine the transformative role that artificial intelligence technologies play in supporting the sustainable development process, by exploring ways to harness these technologies responsibly and ethically to achieve a more inclusive, safer, and sustainable global future. The research problem is that despite the tremendous progress in artificial intelligence technologies, their unregulated use may lead to negative impacts on societies, such as discrimination, widening the digital divide, and the absence of legal governance. The challenge lies in achieving a balance between exploiting the benefits of artificial intelligence and mitigating its risks. The importance of this research is highlighted by its contribution to highlighting the true potential of artificial intelligence in achieving the Sustainable Development Goals, while developing a future vision to regulate and guide its use in a way that serves humanity and mitigates its ethical and social risks. The research tools used were a qualitative analytical approach based on the study of secondary data from international reports, economic statistics, and government and private initiatives. The research was also based on a review of scientific literature and reports

related to the field of artificial intelligence and sustainable development, as well as statistical methods. Economic indicators and global forecasts related to the returns of artificial intelligence were used, such as: AI's estimated contribution to global GDP will reach $15.7 trillion by 2030, and global spending on AI technologies will exceed $500 billion by 2024. The research results indicate that AI enhances resource efficiency and supports innovation in vital sectors such as health, education, and energy. There is a legal and ethical gap in regulating the use of artificial intelligence. The risk of discriminatory applications and harmful technologies poses a threat to human rights. The digital divide between countries may deepen economic and social disparities. Some recommendations include establishing clear legal and ethical frameworks to regulate artificial intelligence, supporting digital education and AI skills in developing countries, strengthening international partnerships to achieve responsible innovation, enhancing cybersecurity related to smart applications, and establishing independent oversight bodies to monitor the use of artificial intelligence.

Keywords: Artificial intelligence, scale, sustainability, digital infrastructure.

الذكاء الاصطناعي ومستقبل البشرية: نحو تنمية مستدامة قائمة على الابتكار المسؤول والتكنولوجيا المتقدمة

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الملخص :
يهدف هذا البحث إلى دراسة الدور التحويلي الذي تؤديه تقنيات الذكاء الاصطناعي في دعم مسيرة التنمية المستدامة، من خلال استكشاف سُبل تسخير هذه التقنيات بشكل مسؤول وأخلاقي لتحقيق مستقبل عالمي أكثر شمولًا وأمانًا واستدامة. ومشكلة البحث على الرغم من التقدم الهائل في تقنيات الذكاء الاصطناعي، إلا أن استخدامها غير المنظم قد يؤدي إلى آثار سلبية على المجتمعات، مثل التمييز، وتوسيع الفجوة الرقمية، وغياب الحوكمة القانونية. يتمثل التحدي في تحقيق التوازن بين استغلال فوائد الذكاء الاصطناعي والحد من مخاطره وتبرز أهمية هذا البحث من خلال مساهمته في تسليط الضوء على الإمكانات الحقيقية للذكاء الاصطناعي في تحقيق أهداف التنمية المستدامة، مع وضع رؤية مستقبلية لتنظيم وتوجيه استخدامه بما يخدم البشرية ويحد من مخاطره الأخلاقية والاجتماعية. و أدوات البحث أُستخدم المنهج النوعي التحليلي القائم على دراسة البيانات الثانوية من تقارير دولية، وإحصائيات اقتصادية، ومبادرات حكومية وخاصة. كما استند البحث إلى مراجعة الأدبيات العلمية والتقارير ذات العلاقة بمجال الذكاء الاصطناعي والتنمية المستدامة و الوسائل الإحصائية تم استخدام المؤشرات الاقتصادية والتوقعات العالمية المتعلقة بعوائد الذكاء الاصطناعي، مثل:تقدير مساهمة الذكاء الاصطناعي بـ 15.7 تريليون دولار في الناتج العالمي بحلول عام 2030 وتجاوز الإنفاق العالمي على تقنيات الذكاء الاصطناعي حاجز 500 مليار دولار بحلول عام 2024 و نتائج البحث الذكاء الاصطناعي يعزز كفاءة الموارد ويدعم الابتكار في قطاعات حيوية كالصحة والتعليم والطاقة.توجد فجوة قانونية وأخلاقية في ضبط استخدام الذكاء الاصطناعي خطر التطبيقات التمييزية والتقنيات الضارة يشكل تهديدًا لحقوق الإنسان.والفجوة الرقمية بين الدول قد تعمّق الفوارق الاقتصادية والاجتماعية و بعض التوصيات وضع أطر قانونية وأخلاقية واضحة لتنظيم الذكاء الاصطناعي ودعم التعليم الرقمي ومهارات الذكاء الاصطناعي في الدول النامية وتعزيز الشراكات الدولية لتحقيق

الابتكار المسؤول لتعزيز الأمن السيبراني المرتبط بالتطبيقات الذكية وإنشاء هيئات رقابة مستقلة لمراقبة استخدام الذكاء الاصطناعي.

الكلمات المفتاحية: الذكاء الاصطناعي، النطاق، المستدامة، البنية التحتية الرقمية .

1. Introduction

Artificial Intelligence (AI) has been identified as the dominant innovation technology and frontier of the Fourth Industrial Revolution. It has the potential to transform societies, economies, and industries worldwide. AI is rapidly changing the world. AI could contribute $15.7 trillion to the global economy in 2030, more than the current estimated GDP of either the US or China. Global spending on AI technologies is expected to exceed $500 billion by 2024. Developing ethical AI is central to the achievement of the AI International Establishment Board's 'Mission 2040': to promote equality and environmental protection, prevent sophisticated future warfare, brain-computer integrated development, combating discrimination against AI, responsible AI technology generator, application of large-scale intelligent business and advanced information protection for blockchain technologies.

The Earth is currently at a crossroads between environmental degradation and significant changes to mitigate and adapt to climate change for the sake of sustainability with growth for all. The Global Sustainable Development Goals (SDGs) were thus drawn up and adopted by the United Nations in 2015. To promote those 17 ambitious global goals, AI can be a useful supporter. In addition to providing a global view, this journal also explores the current status and future trend of appalling potentialities to achieve the Global Goals on Sustainable Development [1]. The ten insightful strategic objectives, which need to match in order for 2030 to achieve the SDGs, such as Implementation of legal, regulatory and business models addressing new and existing AI risks, Elimination of all harmful and discriminatory applications of AI-driven technologies to ensure that AI remains beneficial and safe, Development of a high level of digital and cybersecurity infrastructure and the

promotion of AI technologies and internet platforms follow clear security rules.

2. Understanding Artificial Intelligence

Not so long ago, Artificial Intelligence was relegated to the realm of science fiction. From the first conceptual glimpses of the 1940s and the 1950s, it seemed a technology doomed to remain forever futuristic, a fantasy good only for Turing Tests and Asimovian imaginings of robot maids. But today, suddenly, it is everywhere—or nearly so [2]. For many consumers, the most immediate changes brought about by AI in recent years have to do with work. For the last years, the conversation about living in a world of Artificial Intelligence has been about the future. But most people understand now that the future is already here and will only become more deeply embedded, even as we might not all entirely grasp how today's currents will shape our world over the long term [3]. Depending on who you ask, this might be cause for elation, consternation, resignation, or some combination of all three. Nearly all commentators agree on one thing: There are major changes ahead as AI technologies become more and more advanced and entwined in our daily lives. Implementing artificially intelligent processes may lead to more environmentally sustainable and more socially inclusive forms of development, provided that this technology is underpinned by a responsible innovation approach, a stakeholder engagement process and embedded in sound governance systems. Advanced technology, namely machine and deep learning, can provide relevant advantages when it comes to the process of informing and shaping development policies, social progress and ultimately fostering a more equitable global economic growth.

2.1. Definition and Scope

Artificial Intelligence (AI) has been recognized as a highly transformative technology with the potential to both alleviate and exacerbate a variety of complex global challenges, making it paramount for facilitating the achievement of the 17 United

Nations Sustainable Development Goals (SDGs). However, AI technologies can pose significant and unexpected risks in terms of both individual and societal integrity, most of them little understood by non-experts due to their cutting-edge nature. Recent years have seen prolific effort in mainstreaming AI Ethics and high-level policy standards meant to control them. Such efforts have largely fallen short of impactful change, however, as they are unable to pierce the abstraction gap between high-level values and concrete operative implementation. Thus, in order to allow for the responsible rise and use of AI, there is an urgent need for operationally effective and globally transparent norms that can be enforced at a technical level in a way that is both adaptable to diverse applications and flexible over time. Until then, AI technologies are exposed to a variety of unintended uses that stand at odds with broader developmental outcomes, hindering concerted effort to direct them in a controlled and beneficial way.

AI as a solution can be targeted at each goal individually, or can provide broader support in cross-cutting areas. However, the current state of concern and enthusiasm around AI poses potential ethical and practical risks that present an obstacle to understanding AI's actual capability and potential risks. Therefore a comprehensive view back and ahead, aiming to bridge this gap by first introducing an overview of AI itself (its architecture, methods, application areas, challenges), then showing concisely how these concepts interact with the SDGs both in terms of benefits and challenges.

2.2. Historical Development

The development of artificial intelligence (AI) can be traced back to Turing and von Neumann's at the beginning of network computer in 1940. For years, both success and failure development trends of AI have been summarized, especially for failures like Lighthill's and AI winters. In the analysis, learning theory, neural networks, and philosophical thinking with techniques have been combined. There are some similarities between the development of AI and the understanding of human

cognition. Both experience early successes and later failures. As many past failures come from unrealistic technical and philosophical assumptions, recent successes stem from more realistic ones [4]. Statistical natural language processing (NLP) has been largely successful. Generative models from the statistical traditions were replaced by discriminative models. And boosted by a series of empirical successes dropping additional structures and engineering complexity. Recently complex deep learning models that learn distributed representation from large data have been shown to outperform many traditional models. The volume and quality of data have become more important and determined the pace of research improvements. This reflects the long-time understanding in the NLP community. NLP paradigm shift from knowledge-based to data-driven has occurred in individual areas over time scales of several decades. The simplicity, scalability, and efficiency of maximum entropy have played a key role in the convergence. To address the limits of 'narrow' or 'weak' AI, also known in the literature as 'creative' or 'robust' AI, GAs or 'full' AI, 'strong' AI, also more imaginatively as 'real', 'strong' or 'high' AI, or as the 'first' AI [3]. The development of AI has had some parallels in the development of ethical thought about technologies. AI has raised many philosophical questions. The AI 'agents' in a significant way meet the automatic intelligent robot criterion. Under the comparative definitions of Aristotle and Aquinas an AI agent could be seen as applying ethical reasoning akin to these narrow definitions. Similar conclusions have been drawn by those interested in the legal treatment of intelligent robotics.

2.3. Current Trends in AI

Artificial Intelligence (AI) is setting foot in every domain of information technology; therefore, careers generated by this blooming technology tend to increase. The present education system must adapt itself for this radical change and prepare students with strong roots in this technology. Sustainability can be enhanced by adopting various emerging technologies like AI,

Internet of Things (IoT), Clean and renewable energy, etc. A career in AI has been among the top-paying, in-demand careers because the Top 5 Tech Companies have invested in AI and are using tailored AI technologies like Alexa for Amazon, Tesla for Tesla Inc., etc. From Health, Transport to Technology and yet other sectors, AI is dominating almost every sector [1]. AI is still peaking in development and its ethical and responsible use is a crucial current topic; there is a powerful rise of ethical AI worldwide, followed closely by further legislative measures to be taken. Analysts suggest the trends to keep an eye on data wrangling to data cleaning, discovering, enriching, managing, etc. and robotic process automation. AI used for auto-generating and healing are well-known techniques inside the graphics sector. Significantly more automated generators, synthesizers and alteration applications can be seen on the sketching artists, music or stock photo sectors.

By producing arrangements with information from multiple datasets, the opportunity of an undisclosed story told by the data could be identified and deepened investigation carried out. This is most typically applied by law enforcement; however, this strategy may be adapted very plausibly in a range of different sectors. Medicinal domain is starting to provide patient-specific care by utilizing ML and AI systems; this form of innovation transforms the whole healthcare machinery. It is expected that approximately 80% of society is going to feel the effects of these advancements; domains like medicine, law and education are going to be redefined or adjusted due to AI until 2022. Within the employment sector, tasks that are simple or repetitive will be replaced or highly assisted by AI. Additionally, brand-new forms of employment are anticipated to emerge in domains that did not even exist several decades ago. The majority of employment sectors will take a blow due to the development of AI since 2018. AI transformation thus needs to be balanced with transforming education [5].

3. The Role of AI in Sustainable Development

Modern science and technology are at an unprecedented pace. Many concepts such as the internet of things, cloud computing, and big data have brought about changes in the world, and artificial intelligence (AI) is undoubtedly the leader in future scientific and technological progress. Although the development of AI is accelerating, it is very likely that AI technology will become the most important technology in the middle to long term of the 21st century, but some problems still restrict the development of AI. Therefore, the development of AI can be accompanied by the advanced technological infrastructure. Based on this information, the remaining efforts are focused on three questions: how AI technology will become the most important technology in the future, what problems and challenges are faced in the development of AI, and how AI can be combined with advanced technology infrastructure. Finally, some forward thoughts about the application and future development of AI are put forward according to its own scientific research direction and experience.

The scientific revolution and the industrial revolution promoted the leaps and bounds of the development of human society. After more than 200 years of development, the industrial civilization with steam engines, mechanical equipment, railways, and electric power as the representative has been formed. However, in the last century, with the breakthroughs in information transmission technology and computer technology, the rapid rise of the information society has created the conditions for entering the deep water of the fourth industrial revolution. This revolution features the internet of things, cloud computing, and big data technologies. These technological innovations have affected the overall development of various industries and sectors of the economy [1]. The application of these technologies in the industrial sector to improve production efficiency has led to a new round of scientific and technological revolutions and industrial changes. On the road to the development of intelligent technology, AI was born in the forties and fifties of the last century. After nearly 70 years of

development, AI technology remains the most cutting-edge technology in the field of science and technology. With the continuous maturity and development of AI technology, it is likely that AI technology will become the most important technology in the mid-to-long term of the 21st century, which will have a profound influence on society and economy.

3.1. AI for Environmental Sustainability

Artificial intelligence (AI) is a powerful tool that is used to foster the ambitious and meaningful goal of advancing environmental sustainability. It is well suited to predict, optimally operate, and lead innovation in areas that are greatly connected to the environment. AI can be used to model systems and anticipate their evolution, to analyze and classify large and diverse datasets, to optimize processes and resources, and to invent new technologies. Recent advancements in computing and algorithmics have taken AI applications to levels of performance overpassing human capacities in some specific tasks. This makes AI an invaluable ally to mitigate environmental issues and promote a sustainable balance. A growing concern in society is the way AI technologies should be deployed and regulated, not only to ensure they address legitimate concerns and respect fundamental rights but also to open up AI application for the benefit of all, particularly in the neediest parts of the world [6].

AI and the solutions it provides must confront humanity to different challenges related to responsible and social usage and the definition of the best possible technological ingredients and applications. There is a growing awareness of the positive impacts that AI technologies can bring to society and the economy and of the risks and challenges that they may pose. In order to mitigate those negative aspects and foster the positive ones, different initiatives and approaches have been taken by governments, international organizations, and the scientific community. Experience and discussion are shared on how to define a global framework that builds on multidisciplinary research and sets the agenda for the responsible and sustainable

development of AI. These reflections are informed by the scientific literature and by the contributions and debates existing in various international fora dealing with AI challenges. Artificial Intelligence (AI) could contribute to a significant shift in development paradigms towards more sustainable and environmentally friendly models, notably through the promotion of eco-innovation and sustainable consumption and the provision of new digital instruments. From a theoretical perspective, AI broadly comprises data-processing systems built following algorithms inspired by human intelligence, with the ability to reason, learn from data, generalize and perform autonomous decisions. From a more operational perspective, many tools can qualify under AI, including deep learning, machine learning, data mining, bio-informatics and expert systems, together with data visualization and advanced statistics. AI is considered as a general-purpose technology that can affect several aspects of the economy (production, infrastructure), society (education, work) and political life (security, governance).

3.2. AI in Healthcare

AI powers the digital age. AI and machine learning are not specific systems or applications. Instead, they refer to models and technologies that emulate human cognition to generate outputs based on inputs and the algorithmic adaptation of "rules," training examples, and hardware through scores or rewards [7]. Policies and norms need to be established to clear up an ambit that continuously evolves. Legislation has been devised to approve and regulate hardware devices, health information, and apps built to diagnose, treat, or manage disease. These devices are certified based on their technical specifications to ascertain that they are safe and easy to use. In the case of software as a medical device (SaMD), new policies must be developed in order to approve and regulate such devices, as they rely on evolving algorithms trained on complex sets of data points. After the collection of a "de novo request," manufacturers who have achieved "organizational excellence"

can obtain exemption from premarket review for low-to moderate-risk products, jumping into the "streamlined pathway" instead. The potential of such AI devices is enormous, especially in healthcare, due to the vast amount of data present in electronic health records (EHR) and the important decisions deriving from it. There is hope that AI in healthcare may enable better disease surveillance, early detection, improved diagnosis, novel treatments, and personalized medicine. AI can help recognize patterns in data that human experts would fail to detect, and health data include, besides genetic information, clinical, social, and behavioural data. Many of these data are conveyed in the form of images, like computed tomography (CT) or magnetic resonance imaging (MRI), or time series, like the data acquired by Internet-of-Things (IoT) devices. In other words, the disease is classified by its biomarker, and it is thus likely that class-specific "latent" variables can be extracted from their data. The process dependent on such variables is unknown, since medical imaging is essentially prophetical – it futural helps labelling diseases based on the visible effect on human tissues. The advent of deep learning has powered AI healthcare applications. Indeed, deep learning has triggered a remarkable increase of AI research in medicine: more than 28,000 papers were published in the past decade, over a third in radiology.

3.3. AI in Education

Artificial intelligence (AI) has the potential to transform teaching and education in general. Much of the current AI-driven work focuses on developing intelligent learning platforms and educational software for facilitating, automating, or providing feedback on classroom activities, homework, exams, and mandatory student projects. Many AI-based educational tools are rapidly infiltrating our schools, changing student-teacher dynamics and student expectations. This might also affect the teaching profession, with AI driving partial automation of the teaching process and providing support similar to the way software has begun to replace (at least

partially) white collar jobs in the financial, law, and journalistic sectors [8].

AI in education is gradually becoming a common phenomenon in the modern education system around the world. Artificial intelligence technology is an advanced area of technology that can be effectively used for all types of services all over the world. The impact of AI in the education system depends on various AI technologies. Artificial intelligence is a discipline in designing intelligent machines and systems with the power to solve complex problems. In this era, AI has the potential to change the world, especially in the developing countries like Bangladesh. The central objective of this paper is to provide an outline of AI, its applications in education system and artificial intelligence-based models in the education system [9].

Quality education, one of the Sustainable Development Goals identified by the United Nations, stands to benefit from the adoption of artificial intelligence (AI)-driven tools and technologies. The boom of necessary infrastructure, digitized data and social awareness has propelled research and development in the artificial intelligence for education (AIEd) sector. This analysis investigates how artificial intelligence, machine learning and deep learning methods are being utilized to support students, educators and administrative staff. Additionally, the involvement of AI-driven methodologies in the education process from university or school admissions, course scheduling to knowledge delivery and performance assessment is explored. Furthermore, the major research directions under proactive and reactive engagement of AI in education are outlined.

4. Responsible Innovation in AI

AI has the potential to contribute to achieving the UN's Sustainable Development Goals. However, to achieve desired outcomes, it is necessary to engage in responsible innovation. Thus, to begin the development process of AI technology, ethical guidelines should be considered. The Responsible Norms framework can assist the interpretation of procedural and social

norms, offering advice on how to utilize such norms to shape the impact of AI in socially accepted ways. Subsequently, the interpretation of responsible AI in light of the RAIN framework is proposed. Beyond describing the RAIN framework, it operationalizes its components with an initial consideration of regulatory perspectives, to identify relevant guidelines to substantiate the procedural norms. The framework is intended to support high-level control of AI development and deployment to encourage an efficient and direct vectorization of AI technologies towards the common good. A collaborative effort of AI-related ethical experts on both researched technical and regulative levels could increase the likelihood to shape it in a socially benefitting way so to take advantage of AI for the overall global sustainable development and avoid undesired outcomes. However, there is currently insufficient procedural and normative means to assure a positive outcome of AI technologies. Thus, the Responsible Norms framework is introduced, offering a novel abductive model that interprets procedural and social norms. At the same time, the AI model offers practical advice about which specific computational tools to use and how to deploy them to conform to such norms. The framework can serve as a boundary object connecting these domains and assist in a global effort to direct AI technologies goal-conformingly.

4.1. Ethical Considerations

Introduction to the series on artificial intelligence (AI) and the future of humanity. Its importance arises due to the rapid growth and wide scope of AI as one of the most transformative technologies of the Fourth Industrial Revolution. This creates a future either of major benefits or serious threats. The former demands a substantially increased level of large-scale global cooperation, but this is challenging in the current context. The ethical and governance issues related to pursuing a sustainable future for AI development are explored in a particularly critical light. It is suggested that successful cooperation may be possible, and mutually advantageous, if pursued within the

framework of Responsible Innovation applied to developing AI for social good, and Advanced Technological Education applied to the associated needed capacity enhancement. Societies are on the cusp of major transformations brought about by a range of cutting-edge technologies and the even more rapid advances that can be confidently predicted for them. Many shining promises are made, but there are likewise numerous dark fears. The question is posed of how best to relate to these technologies given the great value that they could have in solving the innumerable challenges that have so far been so difficult to manage, let alone approach. Discarding what has already been abandoned as interfering with sustainability, inclusiveness or the survival of the democratic state, there appears to be only two mutually reinforcing paths forward. The broadest possible collaboration is to be pursued with the purpose of implementing a substantial governance of AI agenda, that pursues its progressive shaping for the common good through an evidence-based approach with broad multi-stakeholder engagement. For such management efforts to be far better targeted, it will be enhanced by seizing upon capabilities enhancement policies, particularly on the spectrum of learning and education, so as to better anticipate what is to come. It is a sign of openness to experimentation and innovation, putting trust in the power of research and making good use of the experience.

4.2. Transparency and Accountability

A multidimensional framework composed of five pillars for robust and ethical AI operation in organizations is presented. These pillars collectively provide a methodical and unified vision for organizations looking to foster the responsible use of AI systems. PILLAR I (Ethical culture and training) focuses on embedding the company’s values into all aspects of AI development and use. Continuous training in the understanding and application of these values is a critical requirement to maintain all employees aligned with the ethical identity of the company. The foundation of this pillar is to involve every single actor within the organization in a process of constant review and

alignment with the moral values of the organization. Of particular interest is the design of continuous training programs combining technical knowledge with a deep understanding of how the company's value system can be embedded in everyday decision-making processes. To this end, it is advised to put into practice a series of formal processes and policies that translate the organizational values into practices and systems that are less ambiguous. Examples in this regard include the realization of audits to assure that the code written by the company complies with the ethical framework, certification of the datasets used in the development cycles, or the establishment of a series of rules and protocols on data privacy that are rigorously enforced. PILLAR II concerning AI governance, transparency, and accountability is essential for guaranteeing fair, transparent, and responsible AI operation within companies. AI ambassadors, or other specially designated roles, are identified as important to ensure data quality is maintained at all costs and to offer a continuous feedback loop that enables the decision-making actors a close-up view of AI operation across all scenarios. Because of the complexity of this task, solid governance structures are put in place, including multidisciplinary ethics committees and continuous monitoring mechanisms. Such bodies are in charge of overseeing that the development and use of AI complies with a series of ethical principles that have been established in advance. Under this pillar, a line of work is developed to engage and promote the ever-growing field of interpretable and traceable AI systems ([10]).

4.3. Public Engagement and Trust

The availability of people to exploit a new commercial service based on artificial intelligence is a significant factor for over 47 percent of AI developers. This represents a substantial increase compared to the share of basic (29 percent) or advanced (21 percent) researchers who agreed with the statement. Firms and AI developers are important agents for an effective policy implementation. They should pursue responsible innovation through an appropriate social shaping of technology approach.

This involves a strong commitment to engage the public and other relevant actors in the technology assessment and development process. The fostering of public trust and the clarification of what the various stakeholders expect from each other are central components of their responsibilities.

A survey was conducted to investigate attitudes and perceptions toward artificial intelligence among the European population. Results show that 41 interested persons have encountered information on AI in the previous year. Differences in such awareness across the EU member states have been highlighted. Respondents to the survey have expressed their dominant fear about robots and artificial intelligence. The data gathered for this paper indicate that individuals appear to have more trust in AI regulators than they do in the developers of AI systems [11]. Over the past few years, governments have increasingly supported AI research. More resources are still needed for the public sector to match the investments of tech companies. There is an overall agreement on the importance of AI developers either in academia or in the industry to obey to a code of conduct. This concern has been expressed by 79 survey respondents, with no significant differences across gender, age, work, AI competence, and trust in AI regulators.

5. Advanced Technologies Supporting AI

The ever-accelerated adoption of AI in the world raises a host of important and complex questions, the most critical of which pertain to the use and implications of advanced technologies to automate decision-making [1]. With AI proliferation in societal contexts, there is concern about human agency attaching to AI decision-making, and, thus, about embedding a point of diminishing returns or leading to certain types of uneven technological development. A common discussion of these concerns comprises a history of analytical work aimed at shaping AI systems, a critical agenda focused on geopolitics and extra-societal relations, and a deep theoretical literature in philosophy, ethics, and political science that draws on historical inquiry into forms of intelligence and uses of information. The

central thesis begins as an elemental exploration of this problem and proceeds by assembling insights from these literatures into a formulation of some of the most critical components of the challenge that is posed by AI. It submits that despite its ambitions, the horizon of AI remains bounded by the nature of the intelligence that is sought, as well as by the abstractedness of its context. With AI proliferating as an existential threat, and subtended by a neoliberal ideological architecture, the imperative task is to engineer interactions among advanced technologies that are characterized by durability. Such designs are habitable, require systems of intelligence that recognize AI's limits, and emphasize action as a form of deliberation. Heterodox results follow from this framework.

5.1. Machine Learning and Data Science

The transformative power of recent advances in artificial intelligence (AI), together with rapid parallel advancements in related domains, such as big data and the internet of things, now has the potential to address even humanity's most critical issues. But it will take a broad and inclusive domain knowledge distribution, along with responsible thought leaders and process governance, in order to fully unlock and realize the opportunity for profound positive impact. The initiative encourages and would greatly benefit from cross-disciplinary collaboration across sectors. Contributions of practitioners, particularly when directed in close collaboration with domain expert civil society partners and researchers, can be uniquely situated to deploy AI in ways that protect, educate, care for, support, and otherwise benefit the world's most vulnerable populations.

AI-driven prediction tools are set to bring huge social benefits, but also some problems in already-troubled sectors. AI's influence is mostly studied from economic, ethical, and security standpoints, yet its vast environmental aspects are mostly ignored. Artificial Intelligence (AI) is often considered the most revolutionary technology of our time – with its potential to have an impact in virtually all aspects of life worldwide, assisting or even executing various dangerously demanding activities and

tasks, creating entire new tiers of technologies, worlds, and jobs, etc. The complexity of this technology is vast, but with its rapid appearance of more and more new branches, training AI algorithms, it gradually becomes more accessible to a wider circle of society – among AI specialists. However, the environmental consequences for all the abstraction are vastly reduced, and will become an unbearable ecological burden for humanity in a couple of decades, if not solved in time.

5.2. Robotics and Automation

Greater efforts should be made to develop beneficial AI technologies, ranging from artificial intelligence for social good in health, economic growth, and environmental sustainability, to automation for sustainable development that creates new opportunities and mitigates risks. International and national governance are less developed with respect to benefits and risks of AI. Research on economic and social challenges of AI can play an important role, e.g., by studying the demand for new labor, the financialization of AI, AI for political communication, spending, and control, as well as the need for intelligent transparency in algorithmic trading. It is urgent to create a resilient platform for sustainable development that deploys AI efficiently and ethically. To endure, this requires governance that includes capacity building, open innovation, and accountability.

Public education about the inability of robots to have feelings or form genuine bonds with humans will likely not be enough to prevent such harms; shrewd AI developers could exploit such misconceptions to deepen attachment to their devices through simple robot social agent enabled design tweaks. It is thus imperative that lawmakers and developers of AI-enabled social agents begin to work together on ethical and legal guidelines for restricting or prohibiting harmful manipulation. Rapid developments in machine learning technology have allowed AI programs to increasingly outthink their human creators and patrons in ways not fully understood by either party. From a technical standpoint, AI programs learn to make increasingly

complex decisions by adjusting their network connections according to patterns revealed in massive datasets. But as sociotechnical systems, AI programs influence human ethics by training them in new belief strategies they may not fully appreciate or understand. This issue is investigated through a series of case studies in the development and deployment of big data and AI prison reform decisions. The automation bias is the psychological phenomenon in which humans greatly overestimate or rely unduly upon the capabilities of computerized systems. Automation bias can result from flawed expectations of computerized systems as infallible or inherently superior to human judgment. The latter is often elicited on the basis of only shallow similarities with intelligent human behavior. A notable example of this phenomenon's salience to the field of AI ethics was the role played in a disaster by operators' faulty deference to an anti-aircraft system. Almost unanimously, AI scientists argue that robot intelligence still greatly differs from human common sense. Judicious deliberation of AI ethic is essential for creating disruptive robots in order to avoid threatening the humanity.

5.3. Blockchain and AI Synergy

The real-world applications ranging from trade finance, food supply, medical, and genetic data sharing, to entertainment of blockchain have fascinated numerous communities to develop blockchain-based systems. The system of blockchain is constructed by connecting chained blocks. Transactions or data changes are append only made in the new generated block and chained with the earlier one. Utilizing consensus algorithms, all the records on the blockchains are distributed and shared among the cooperating peers who form the blockchain network. Security concerns on blockchain, connected with smart contract attacks, consensus diverge attacks, and 51% stake attack are studied. The architecture of malicious blockchain may be exploited as another proof of blockchain-based Sybil attacks. Some recent blockchain Sybil attacks towards traditional blockchain systems are sustained. Blockchain has received

extensive attention as it accents for providing secure data sharing services with traceability, immutability and non-repudiation. Immutability of blockchain sustains the unchanged and chronologically ordered characteristics of the data. However, the integration of AI with blockchain has the potentials to overcome these limitations. The blockchain data is usually saved in the local storage or distributed among the blockchain cooperating peers. The blockchain node stores the blockchain data for verifying and verifying the trusted blockchains. Simultaneously the blockchain node also stores some metadata such as the latest trusted block information. After joining the blockchain network, the blockchain cooperative nodes will download a complete version of the blockchain system. Additionally, the blockchain cooperative peer also has the capability to assess and identify the smart contract. With the widespread applications of blockchain, the security and privacy of blockchain systems are attracting much attention for the researchers. Recently many efforts have been made to secure the blockchain network, vulnerabilities in blockchain are being explored. AI approaches may help to capture the abnormal behaviours in blockchain after analyzing the blockchain data. An AI model can be constructed and normal behaviours such as accessing blockchain metadata for verifying and appending second transactions can be trained. With the blockchain alert and the AI model, proactive and autonomic switches can be developed for appellations to prevent blockchain from disruptive actions [12].

6. Challenges and Risks of AI

Artificial intelligence (AI) is a key technology that shapes today’s economy, society, and politics as no other technical innovation. It will increasingly influence the future of a multitude of thematic areas, including progress in fundamental fields, such as research and education, technologies and their applications, market developments, and structural and macroeconomic traits of economies.

However, while offering enormous opportunities, AI also poses a variety of challenges and risks: "technological unemployment," a narrative that has been present since the industrial revolution; opacity or lack of transparency, the technology's inability to explain its decisions; privacy and concerns as to how the technology "intrudes" upon subjects' personal life; risks resulting from an AI system's autonomous decisions; ethical concerns regarding the fairness and legal treatment of individuals; loss of personal autonomy for the same reason. Additionally, there are technical risks, such as an AI system's susceptibility to adversarial manipulations. And there are "information risks," that the AI system's effects can be nullified if adversaries can feed them manipulated or purposely selected data [13]. To ensure that AI and other advanced technologies meet the Sustainable Development Goals (SDGs) of the United Nations, it is essential to bypass these challenges and risks. This requires an AI development and application that is guided by the goals, kudos, and principles of sustainable development, responsible innovation, and Responsible Research and Innovation. Advanced technologies should contribute to collective goals such as a just and fair society broadly or maintain a healthy environment, even if individual technology applications do not [14].

6.1. Job Displacement

Even though AI, automation, and robots are revolutionizing workplaces, the newest evidence shows that potential job immiseration is a false alarm. The key reason is that market economies have demonstrated their flexibility to successfully transform in the past. The fourth industrial revolution will not make past economic performances irrelevant. Moreover, AI, automation, and robots, being still far from delivering the over-hype possibilities fantasized by some prophets, are not going to turn the world around overnight [15]. There are, however, good reasons to believe that the dynamics of change at work will entail significant adjustments. Those will be salient in terms of the acceleration of an on-going trend related to the emergence of

a new ‘skills race’ among countries. The competitive landscape will be configured so that differences in ‘learning capacities’ will be increasing. In their turn, this is generating a dual-expression mode in terms of new divides, contrasting between the many as well as the few, and perhaps unveiling the core of a future global order reconfiguration. Grounded on these premises, the focus is on the future sustainability of current patterns of development, and more specifically on the policy and ethical implications related to the design and governance of national growth strategies. It is argued that the pervasive quest for competitiveness will become increasingly intense. A historical analogy is established with other periods of accelerating change— such as the late 19th and the post-WWII American experiences—where development strategies centered on the cultivation of new essential technologies. It is claimed that this constitutes but one potential development path amidst broader alternatives. Furthermore, it is suggested that the pursuit of ambitious objectives in terms of employment, social cohesion, and environmental sustainability will play a vital role in the discernment of those paths which are more conducive to long-term prosperity maintenance. This leads to the proposal of a ‘smart sustainability pact’.

6.2. Bias and Discrimination

This report outlines an overview of the initiatives of the high-level expert group on artificial intelligence (AI HLEG) with a focus on the ethical and social issues concerning the impact of AI on the future of work and human society. The AI HLEG responsible for producing ethics guidelines for trustworthy AI highlights challenges posed by the use of AI in the public sector for democracy, bias, transparency, and accountability. There is discussion of the deployment of AI in job enhancement, the need for skills to adapt to rapid societal changes, circulation of good practices, and the synergies between AI, RRI and inclusive societies. New job creation, job enhancement and regulatory and educational adaptation to AI applications Counsel to policy makers and educational institutions is obsessed on: 1) job and

business opportunities supported by AI to evolve in the direction of win-win situations between employees and AI, 2) ensuring that employees are equipped by schools and universities with the abilities and perspectives needed to explore them, 3) preparing students and workers to work via AI primarily based systems, and interacting with AI in both technical and user-facing jobs. The future of work and the overall shape of human society beyond 2020 will be driven mainly by the likely impact of AI and robotics [16]. Technological advancements in AI and robotics will continue to drastically alter how people live and work. Given the foreseeable speedy tempo of socioeconomic changes from the automation of latest work/job types, the job marketplace will need to be regularly tailored. This effort should also entail developing societal systems which facilitate the learning of new jobs after the automation of others. This studying should no longer entirely be and concept of threat or technological in nature, but need to also encompass non-work factors of society causing AI-driven monetary impacts and vice versa.

6.3. Security Threats

Cyber-physical security threats aim to manipulate the physical world the AI system interacts with to cause either injurious effects or to collect targeted data leaked during the normal decision-making process of the system, or both [17]. An adversarial attacker may control the light sensor of an AI-powered autonomous car to shine a flashlight, causing the AI model to malfunction and fail to recognize road signs. Evasion attacks could be targeted or untargeted. In a targeted evasion attack, an adversary actively tries to trigger the wrong decision (outcome) at the output layer of the AI. A nuclear plant supervisor might launch an attack on the industrial AI controller of the nuclear plant to always produce the action result of ‘everything is normal’ through manipulating the sensor reading of high temperature around the reactor core. In case of AI, the attacker could also mount an inversion attack, for example trying to reconstruct the training data given only the AI model.

A data-driven hedge fund can use AI to predict the increase or decrease of the stock price in its trading model. Another hedge fund enters non-break clauses in their business contracts and hires an expert third-party to reconstruct the original data, hence reengineering the model. If successful, either for the evasion or the inversion, the output of the AI will be clearly different from the pristine condition. Note that evasion and extraction attacks are closely related since the mechanism of accurate attack is control over internal data representation. Effects are also sometimes similar; confidentiality (data for evasion and model for extraction) needs access to the internals. Grey-box attacks exploit limited knowledge of the internals of the AI model, while white-box attacks require full access to all model structures and parameters. Most of existing adversarial attacks are white-box or contaminant attacks, using backpropagation of the SoftMax loss with respect to input gradients. In case of cyber-attacks on an AI classifier, however, the traditional gradient-based attack is not always possible. Because if the inputs to the attacked model are transformed into a distribution where the SoftMax (classification) score is close to 0.5, as a result of the non-linearity, it is mathematically impossible to increase the score of one class without decreasing the score of the other class.

7. Global Perspectives on AI and Sustainability

Global AI efforts in the ongoing race to AI technological development are monitored. Efforts are made by certain countries and agencies to adapt AI in a responsible and sustainable way, thus contributing to global development. This includes: (i) regulations, standards, healthcare and transition towards zero-emissions; we are about to switch from the current prototype, which generates 30 Gg-CO2 per 100 GWh of electricity used in three years, to a zero-emission system; (ii) responsible innovation and ethical guidelines; (iii) prospective research and energy of new infrastructures to be developed by 2025 with zero-emissions; (iv) Development of own technologies, software, infrastructures; this might give a

restrictive advantage that compromises all future developments; (v) efforts to support and develop research on AI abiding ethical norms and competitively fostering AI research towards safe-technological development.

Scientific, ethical, economic and political challenges that AI brings in the form of a SWOT analysis [1]. Finally, AI is proposed by high-tech-based countries participating in the race to SDG-s standing out for bio, nano, quantum-tech, neuro, cloud and other types of super AI technologies. It is pointed out that the effect of AI in reaching possibilities, progress, gaps in a broader development, the role of regulators is indicated; AI is more likely to gain a foothold in digital-based states with strong regulations. The economy dominates, thus conceding safe technological development and the United Nations sets up standard guidelines for AI to be followed by member states. There might be a chance that AI would be exploited in a more responsible way, fostering safer global technological development. However, it still raises concerns since the very nature of AI inherently neglects human values. In the long run, it could be pointed out that global implementation of AI might probably negatively affect the whole development of the Earth - a single state might be left behind, conquer the entire development.

7.1. Case Studies from Developing Countries

(1) Five case studies are presented in which Artificial Intelligence (AI) is used in developing countries with the purpose of supporting progress towards the UN Sustainable Development Goals. The technologies aim at improved agriculture, smarter cities, better health, and sustainable environments, but they also have different kinds of unwanted ethical “side effects” [18]. A further study uses this constellation of cases to illustrate how the ethical side effects of AI could be anticipated, avoided, mitigated, or repaired, and it suggests some policies for approaching the ethical introduction of AI applications in the Global South. (2) In recent years there has been a growing interest in how AI can be used to address

complex societal challenges such as health, advanced agriculture, and social structure and environment reform. Considerable financial resources are being employed to this end by governments, corporates, and NGOs. Five case studies have been selected in which AI technologies are used in developing nations to encourage improvement towards the UN SDGs, namely more successful agriculture, smarter cities, health care, healthier environments, and disaster prevention.

The MGI labeled the first three of these illustrations as business process, market model, and enabling model, whereas the ecological illustration has been named an environmental model. In the definitions brought forth by MGI, these models provided UN reports on Sustainable Growth. The MGI suggests that AI should have potential applications in each of the four sustainability categories. Nevertheless, the ethical side effects indicated, and the method of quantitative studies to evaluate them, as well as some analytical thinking to anticipate them, go well beyond the MGI strategies. It is important to bridge this research gap with focus on plans to promote the ethical introduction of AI and large-scale data technologies.

7.2. International Collaborations and Policies

As set out in the Pan-African AI Alliance, international collaborations and policies are necessary to propel AI for social good [19]. Through international development cooperation, AI can be promoted to solve global challenges. Similarly, transnational or regional collaborations on R&D&I can boost AI progress. In order to bridge digital divides, it is important to disseminate AI technologies wisely on a global scale. This paper proposed a new collaboration and policy concept called AI4TheGoals. AI4TheGoals is a unique interdisciplinary collaboration combining AI, natural, human and social sciences with sustainable development practitioners. The goal is to establish AI4TheGoals task forces within a number of organizations and research consortia worldwide, each focusing on specific sustainable development goals (SDGs) initiatives.

The concept will be assessed at the international level, thanks to the co-editing framework installation of the TC on AI for developing countries, the organization with African partners of high-level joint events on AI for Africa, and the presentation of the AI4TheGoals concept at UN agencies and European political instances. Similarly, the concept will be pursued at European level with the raising of attention towards European policy makers and the application for H2020 calls on AI and SDGs. Finally, the long-term ambition is to advocate for the creation of coordinated efforts worldwide towards responsible embedding of AI solutions in the service of such development goals, using the AI4TheGoals proof of concept as a support. There is an increasing interest in AI-driven methods and applications, which keep gaining traction due to the development of advanced machine learning and natural language processing technologies. The potential impact of AI technologies on society, accelerated by the Internet of Things arrays and the super-fast connections brought by the forthcoming 5G and 6G mobile networks, is expected to change our lives over the coming years. This paper provides a general view of the development of AI and associated innovation technologies, as stemming from the analysis of their inherent possibilities and pitfalls. A series of key aspects are discussed as to mitigate issues related to the development of advanced AI and associated technologies, most of which are part of the European continent strategic agenda, by anchoring this new aspect in the field of Responsible Research and Innovation.

7.3. Cultural Impacts of AI

A critical discourse has emerged those questions the impact of digital technologies and artificial intelligence (AI) on contemporary society. These analyses challenge the prevailing narrative that all technological innovation is inherently positive and beneficial. Instead, they highlight the potential risks of excessive technologization that could erode human autonomy and even have a negative impact on civilization. By so doing, they join the philosophy and sociology of technology, which have long warned of the dark side of innovative activity. Despite

the many benefits that can be gained from the professions by the advance of technology, there is no certainty that the course of global technological development will necessarily turn out to be "good" for humans. This critical approach will analyze how digitalization and the rise of generative AI, the most recent and advanced technology in the field, are radically reshaping not only the ways of working and socializing but also the economic structure and cultural landscape of European societies. To pave the way for this exploration, an understating is first provided to the legal and conceptual framework within which such technological developments are unfolding.

However, it is also recognized that the impact of innovation is not deterministic and that many actors can and do play an active role in shaping the transformation of organizations and society. Governments, academics, civil society, and other stakeholders can take a forward-looking stance and develop and support innovation policies that promote the desired change. It is underscored, then, that a strong role can be played by establishing an ethical approach to innovation, indeed. It called for innovation to be approached not only from the techno-economic perspective, but moreover by incorporating a strong ethical dimension into the design of products, processes, services, and, generally, business models that are aligned with human and social values. With the aim to support such approach, a multidimensional framework of how innovation could be encouraged, monitored, and developed will be proposed, which combines ethics with regulation, innovation, and education [20]. It is argued further that innovation in AI, however, complex and potentially game-changing, should not be feared per se and, on the other side, that several actions can be taken to seize its positive aspects, not only by minimizing the negatives but also by promoting the active role of one or more of the aforementioned actors.

8. Future Directions for AI and Humanity

Artificial Intelligence (AI) is one of the main features of the fourth industrial revolution, characterized by a fusion of

advanced technologies and their integration into all sectors. AI technologies hold substantial power to feed into the realization of numerous economic, societal, and environmental challenges, hence transforming industry. Combined with other cutting-edge solutions, such as blockchain technology and Internet of Things (IoT), AI can collaborate with intelligent technologies to give life to a more interconnected future, building sustainable agriculture and rural areas.

AI technology is making a leap on cutting-edge innovations that can significantly impact the course of future development. Many urban elites are working to achieve AI breakthroughs and a more developed and powerful AI industry. In recent years, the involvement of the industrial sector in tackling key technical issues has uncovered transformative findings, including essential advances on advanced data storage for extreme ultraviolet lithography, key technologies and software systems for the basic platform of quantum computers, digital transformation in sectors like pharmaceuticals, and quick breeds of commercial price-photoresist and high-precision lithography equipment. New milestones are anticipated to be driven by greater breakthroughs in these sectors, manifesting itself in the emergence of new scientific and technological revolutions and industrial transformations [1]. To this end, it is pivotal to emphasize on advancing industry participation in the application of cutting-edge technology.

AI’s development needs an improved environment of organized structural diversification. AI’s deep integration with a diverse spectrum of other technologies and various sectors can further adhere to the advent of new models, practices, industries, and patterns of development. Such a process can venture a significant role and formed into an ultimate outline for trade ecology which caters to both national and global markets. On this account, advancements should be impelled in cutting-edge AI technology and algorithm research. Advanced AI intelligent algorithms require significant effort to foster a more enabling collaborative research ecosystem encompassing joint institutions and large and medium-sized enterprises.

8.1. Innovations on the Horizon

With each passing day, greater progress is being made in artificial intelligence (AI) technologies. Together with the advances already described—neuromorphic computing, cloud intelligence, fully homomorphic encryption, digital twins, multi-agent smart systems, and energy harvesting—these achievements are projected to alter all aspects of life in the following years. Including but not limited to language, economics, and personal entertainment, integrated use of AI with these other leading-edge technological achievements should generate a level of innovation and economic growth never before witnessed on Earth. It is hoped that readers are able to move beyond the nanosecond mindset that dominates much of society and contemplate the profound transformations that AI is on the cusp of creating in the years and decades ahead. According to consensus estimates, a full two-thirds of children born today will eventually work in jobs that do not yet exist, over half of which will arise from the ongoing and past effects of AI and illustrated disruptive technologies.

As technologies continue to evolve and branch outward, AI derived enhancements will evolve even more specialized platforms and capabilities. For illustration, discussed a number of disparate and relatively non-obvious disciplines in the preceding sections with the common thread of AI advancements. Each represents merely one among an almost limitless spectrum of potential opportunities arising from the advances presently underway. The landscape and business models of tomorrow are yet to be determined and are really only limited by the collective imagination strove to cultivate within oneself. AI is not "coming" this is outdated pronoun to anticipate the unprecedented technological changes gathering momentum on the threshold of the third decade of the 21st century [1].

8.2. Long-term Implications for Society

New computer-based developments, especially the development of Artificial Intelligence (AI) based on digital machinery, 'neural network' architectures and increasing access to data give

opportunities for a new wave of automation of the economy. As with earlier waves, this offers the promise of increased productivity; this time enriched by learning and 'smart' features. And as with earlier waves, it offers the threat of unemployment and challenges to private skills with the potential to exacerbate inequalities within and between societies. As this wave also brings other, less predictable, changes automation ('smart networked' autonomous systems & robots) the good and bad implications of this is disputed. There are also issues of potential dependencies and vulnerabilities resulting from an ever-tighter hybridization of autonomous systems with critical national, infrastructure and the overall wider biosphere; all these can in certain conditions have catastrophic implications.

While the opportunities and threats of AI and other advanced technology are debated within academia, industry, national policy-makers and international authorities, the general public and the civil society organizations more and more noticeably demand genuine debate and a say in the ongoing development, deployment and governance of these technologies. This is reflected in a growing number of popular books, festival discussions and public petitions related to the fight against lethal Autonomous Weapon Systems (AWS), algorithmic biases & decision-making, brain machine interfaces, children's privacy, Luddism, employment & education in the digital economy, gender biases in the development of AI, inequality or workers' right, health implications of wireless radiations and others [3]. Moreover, all these seemingly separate issues share the common concern for the future of the humanity and the sustainable development of the global society based on the responsible innovation and deployment of advanced technology, primarily AI.

8.3. Vision for a Sustainable Future

The development of artificial intelligence and its applications in a wide range of areas are creating new possibilities for business development and extensive impacts on social development. It helps to promote the solution of complex global challenges that are closely related to sustainable development, such as poverty,

food security, health, education, climate change, energy efficiency, protection and sustainable use of the oceans and terrestrial ecosystem. Acknowledging the universality of AI and SDGs and the sound importance of this intersection in future sustainable global development, there is a general review of the role of AI as a strategic instrument to achieve the SDGs. AI, despite its tremendous promise, has the potential to exacerbate many of the most pressing issues that threaten to make people's planet a sustainable place to inhabit, among other things, climate change, loss of biodiversity, inequality, cybersecurity, and risks from autonomous weapons.

Table 1 shows a SWOT analysis of the role of AI on the capacity to achieve the 17 SDGs by 2030 with insight of the discipline of AI and its sub-areas, and those that transversely impact on other sectors or depend on the advances and development of AI. A strong emphasis is accorded to the 17 SDGs already established by the United Nations as the 2030 Agenda for Sustainable Development. In the analysis, one axis is AI and advances in AI across the areas and its up-and-coming resolution for pervasive humanitarian challenges, on the other hand, one of the main purposes is to examine the socio-economic, legal, ethical, and political repercussions of escalating the intense application of those technologies, and ultimately whether that may prevent the attainment of the SDGs.

9. Conclusion

The exploration of a topic must necessarily have a limit [21] – in this case, the limit of the customary 12,000 words has been reached. However, global trends related to artificial intelligence (AI) and the future of humanity appear almost limitless [1]. It is only guessed at in the title of this focused section.

This means that the AI scene will continue to change at a fast pace and confront people with interesting and challenging developments. The common worry that AI will soon catch up with and surpass human intelligence is subsumed here under the question whether homo sapiens are wise enough in their treatment of their environment and in the organization of their

societies to be justifiably referred to as homo sapiens, a questionable use of the term sapiens given the multitude of faults, limitations, and failures of the humans. On the other hand, research promotes AI as meaning in the progress towards the goals of sustainable development.

Ever increasing processing speed and interconnectivity have been projected far into the future, and they will bring about changes that are currently hard to conceive. As will the fusion of living organisms and machines, like brain implants, chip implants, and machine-enhanced cognitive and physical functions. However, these projections will remain speculative and elusive.

More importantly and much more down to earth, the gains made in the insights of brain function and its technological simulation will not only transform work but defy the very concept of intelligence and creativity. The expertise with which professions earn their living, like analysis, advice, translation, drafting, have a huge proportion of routine work already today that AI can take over from humans. Robots are able to speak, teach, perform surgery, advise on investments. Networking will redefine work procedures and organizations. Major changes in healthcare, economy, society, culture, will accompany the much-praised changes in work.

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Relationship between hypertension and psychology, obesity, smoking and sport in Diyala Governorate in young's and adults between (25-45) ages

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Abstract:
Elevated blood pressure showed a direct correlation with generalized anxiety conditions and significant depressive illnesses. Elevated blood pressure remains a significant global health concern, and emphasis should be placed on initial preventative strategies, particularly among healthcare professionals who serve as a conduit to the broader population. Amendable risk elements for hypertension encompass increased weight and corpulence, inadequate intake of produce, a sedentary lifestyle, job-related stress and smoking beverage intake. The central aim was to ascertain the frequency of elevated blood pressure and pre-hypertension along with their predisposing factors in countryside and metropolitan regions of the province among adult males and adult females within the years of (25 and 45). We conducted a blood pressure test for 100 people from Khanaqin, Jalawla and Sadiah) cities in Diyala Governorate, who were visiting Khanaqin General Hospital and two health centers. A sub-sample of young men and women between the age 25 and 45 years constituted participants for the present study. Research findings demonstrated that people who participate in consistent physical activity do not develop hypertension. Although the study revealed that individuals who smoke have elevated blood pressure, overweight individuals, with females showing greater rates of obesity compared to males, also experience hypertension. The research indicated that a portion of the individuals involved in the investigation lacked wholesome daily routines. This could lead to significant predisposing elements for the advancement of elevated blood

pressure. **Keywords:** high blood pressure, psychology, obesity, sport, smoking

العلاقة بين ارتفاع ضغط الدم وعلم النفس والسمنة والتدخين والرياضة في محافظة ديالى لدى الشباب والبالغين بعمر (25-45) سنة

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الخلاصة:
أظهر ارتفاع ضغط الدم ارتباطًا مباشرًا بحالات القلق العام وأمراض الاكتئاب الكبيرة. لا يزال ارتفاع ضغط الدم مصدر قلق صحي عالمي كبير، ويجب التركيز على الاستراتيجيات الوقائية الأولية، لا سيما بين المتخصصين في الرعاية الصحية الذين يعملون كقناة للسكان الأوسع. تشمل عناصر الخطر القابلة للتعديل لارتفاع ضغط الدم زيادة الوزن والسمنة، وعدم كفاية تناول الفواكه، ونمط الحياة خامل، والإجهاد المرتبط بالوظيفة، والتدخين. كان الهدف الرئيسي هو تحديد انتشار ارتفاع ضغط الدم وارتفاع ضغط الدم الطبيعي وعوامل الخطر في المناطق الريفية والحضرية من الولاية بين الرجال والنساء الذين تتراوح أعمارهم بين 25 و45 عامًا .أجرينا فحص ضغط الدم على 100 شخص من مدن خانقين، جلولاء والسعدية في محافظة ديالى كانوا يزورون مستشفى خانقين العام ومركزين صحيين. وشكلت هذه الدراسة عينة فرعية من الشبان والشابات الذين تتراوح أعمارهم بين 25 و45 سنة. أظهرت نتائج البحث أن الأشخاص الذين يشاركون في نشاط بدني متسق لا يصابون بارتفاع ضغط الدم. على الرغم من أن الدراسة كشفت أن الأفراد الذين يدخنون يعانون من ارتفاع ضغط الدم، وبينت الدراسة ايظا ان الأشخاص يعانون من مشاكل نفسية جمعيهم كان لديهم ضغط الدم المرتفع، إلا أن الأفراد الذين يعانون من زيادة الوزن، حيث تظهر الإناث معدلات أعلى من السمنة مقارنة بالذكور، يعانون أيضًا من ارتفاع ضغط الدم. وأشار البحث إلى أن جزءًا من الأفراد المشاركين في التحقيق يفتقر إلى الإجراءات اليومية الصحية. قد يؤدي هذا إلى عناصر استعداد كبيرة لتقدم ضغط الدم المرتفع.
الكلمات المفتاحية: ارتفاع ضغط الدم، حالة النفسية، السمنة، الرياضة، التدخين

Introduction

High blood pressure is still a global public health issue and primary preventive measures must be prioritized, particularly among health practitioners who are a channel for the entire population. High Blood Pressure prevention, detection, evaluation, and treatment is based on standards set by the World

Health Organization, WHO, and Joint National Committee. The (WHO 2013), defines high blood pressure as blood pressure above 140/90 mmHg when diagnosed multiple times. Hypertension is known as a silent killer because it usually doesn't present any warning signs or symptoms at the initial stage, and many individuals are unaware of their condition. The American Psychological Association (APA) categorizes psychological distress as mood variations that are accompanied by painful physical and mental symptoms, making it a risk factor for hypertension. Anxiety and depression are commonly used to measure it, as Liu et al. concluded that there is a bidirectional relationship between psychological stress and hypertension. Hypertension is caused by modifiable risk factors such as overweight and obesity, low fruit and vegetable consumption, physical inactivity, occupational stress and smoking. Genetics, age, gender, and race are all risk factors that we can't control, according to Casey et al., 2006). For a comprehensive and inclusive high blood pressure management program to be successful, the participation of patients, families, communities, and healthcare delivery systems is essential. The aim of this study was to measure the knowledge that young adults have about hypertension, the management of hypertension and the complications of hypertension. Our goal was to investigate how often psychological distress (depression, anxiety, and stress) is present

Material and Methods

To collect data from various populations, epidemiological studies typically use cross-sectional designs. Accurately measuring blood pressure requires standard protocols, such as using calibrated sphygmomanometers and ensuring appropriate conditions during measurement. The recruitment of representative samples and the handling of confounding variables pose challenges for researchers. The findings of the Hypertension and High-Normal Blood Pressure Prevalence study have already been disseminated, including a thorough account of its structure, participants, and procedures. In short,

this was a population-based, snapshot survey conducted between December and January (2024-2025). The main goal was to find out the rate of hypertension and high-normal blood pressure, as well as their underlying causes, in both rural and urban areas. We administered a blood pressure test to 100 individuals from Khanaqin, Jalawla and Sadiah) cities in Diyala Governorate, who were visiting Khanaqin General Hospital and two health centers. For the current investigation, individuals were chosen from a segment of young adult males and females ranging in age from 25 to 45 years old. We collected information by employing a previously validated questionnaire. The documentation encompassed details regarding fundamental socio-economic and demographic factors, tobacco use, exercise levels, eating patterns, and prior medical background concerning high blood pressure, abnormal cholesterol, and elevated diabetes mellitus. Calibrated sphygmomanometers were used to measure blood pressure on the subject's left arm while they were sitting in a sitting position at heart level and had rested for at least 15 minutes. The participants were required to refrain from drinking coffee, tea, or smoking within half an hour of measuring their blood pressure. The final blood pressure was determined by combining the mean of the last two readings taken 3 minutes apart. We randomly selected 100 people, 40 of them were examined at Khanaqin General Hospital, 35 of them were examined at General Health Center, and 25 of them were examined at Sabaa Nisan Health Center.

Result

In Al-Diyala Province, a study was conducted to investigate the prevalence of high blood pressure among individuals aged 25 to 45 years. One hundred individuals were randomly selected from this age group. The sample was divided into four groups: Group 1: 25 individuals who engage in regular sports, show in (table 1), Group 2: 25 individuals who smoke show in (table2), Group 3: 25 individuals who are obese show in (table3) and Group 4: 25 individuals who psychology shows in (table 4). Data Collection: A complete medical history was obtained for each

participant, including: Name, Age and Gender. Research results showed that individuals who engage in regular exercise do not experience high blood pressure. While the research indicated that smokers have high blood pressure, obese individuals, with women exhibiting higher obesity rates than men, also suffer from high blood pressure. Regarding the final group, psychology, it all had high blood pressure.

Table 1
Systolic and Diastolic Blood Pressure Measurements for a Group of regular sport.

Number	Gander	Age	Systolic (mmHg)	Diastolic (mmHg)
1	Male	40	10	8
2	Male	28	11	6
3	Male	26	12	6
4	Male	45	11	6
5	Male	36	12	8
6	Female	40	11	7
7	Female	38	10	8
8	Female	25	12	6
9	Male	44	12	6
10	Female	30	12	7
11	Female	31	12	8
12	Male	34	12	6
13	Female	37	12	7
14	Male	26	10	8
15	Female	27	10	6
16	Female	33	12	7
17	Female	40	11	8
18	Male	31	11	8
19	Male	40	11	7
20	Male	27	12	7
21	Male	35	10	8
22	Male	27	12	8
23	Male	40	11	7
24	Male	39	12	8
25	Male	40	12	8

Table 2
Systolic and Diastolic Blood Pressure Measurements for a Group of smoking

Number	Gander	Age	Systolic (mmHg)	Diastolic (mmHg)
27	Male	29	12	8
28	Male	40	12	9
29	Male	39	12	8
30	Male	38	15	10
31	Male	37	14	9
32	Male	32	12	8
33	Male	29	11	8
34	Male	27	12	8
35	Male	33	12	8
36	Male	30	12	8
37	Male	34	12	8
38	Male	44	12	8
39	Male	40	15	9
40	Male	40	14	9
41	Male	40	12	8
42	Male	29	12	8
43	Male	34	11	7
44	Male	39	15	9
45	Male	39	16	10
46	Male	45	12	8
47	Male	27	12	8
48	Male	28	12	8
49	Male	40	12	8
50	Male	35	14	9

Table 3
Systolic and Diastolic Blood Pressure Measurements for a Group of obese

Number	Gander	Age	Systolic (mmHg)	Diastolic (mmHg)
51	Male	30	12	8
52	Male	36	14	9
53	Female	33	12	8
54	Female	39	15	10
55	Male	25	12	7
56	Female	32	12	8
57	Female	40	12	9
58	Female	40	16	9
59	Female	29	12	6
60	Female	43	12	7
61	Female	37	12	8
62	Female	39	12	8
63	Female	28	12	7
64	Female	40	14	9
65	Male	40	15	9
66	Female	39	17	9
67	Female	44	12	7
68	Female	27	13	8
69	Female	37	12	8
70	Female	45	12	8
71	Female	37	15	9
72	Female	33	12	8
73	Female	30	12	8
74	Male	26	12	7
75	Male	28	12	8

Table 4
Systolic and Diastolic Blood Pressure Measurements for a Group of psychology.

Number	Gander	Age	Systolic (mmHg)	Diastolic (mmHg)
76	Male	40	16	9
77	Male	36	14	9
78	Male	34	14	8
79	Male	32	13	9
80	Male	27	15	9
81	Male	29	16	10
82	Male	40	14	9
83	Male	31	15	9
85	Male	26	14	9
86	Female	27	14	8
87	Female	45	17	10
88	Female	43	15	9
89	Male	39	18	11
90	Male	40	15	9
91	Male	33	14	9
92	Female	39	16	10
93	Female	40	13	7
94	Male	31	15	10
95	Male	29	14	10
96	Male	38	16	10
97	Female	40	12	9
98	Male	40	12	8
99	Female	28	13	9
100	Female	36	15	8

Discussion

A community survey was conducted to assess high blood pressure and risk factors, and 100 people were tested from Khanaqin, Jalawla and Sadiah) cities in Diyala Governorate, who were visiting Khanaqin General Hospital and two health centers. Based on our results, the occurrence of high blood pressure in adults stood at 37%, surpassing the general occurrence of hypertension, which was 30% in a comprehensive meta-analysis incorporating substantial studies from India

(Anchala R et al., 2014). Furthermore, the prevalence was documented as 29% in the US National Health and Nutrition Examination Survey. (Fryar CD et al., 2017). Blood pressure and hypertension risk are linked to socio-economic and demographic factors (Abubakar et al., 2009). The study examined a well-known belief that normotensive individuals who display substantial responses to mental and physical challenges are at risk for hypertension 21. As age progressed, there was a rise in the prevalence of high blood pressure, as demonstrated in various other studies, Hypertension can be induced by high consumption of smoking and alcohol, which are both relevant influences on blood pressure (Husain A et al.,2014). The incidence of workplace accidents, low productivity, and illnesses has always been linked to work stress (Goyal R et al., 2016). According to the Framingham study, overweight individuals account for 70% of newly diagnosed hypertension cases (Cavagioni & Pierin, 2012). The significance of this study's outcomes suggests that elevated blood pressure can impact individuals across various age groups, both younger and older adults. According to Perry (2002), individuals in developed nations face an increased likelihood of developing hypertension as they age. Whelton et al. ,2003) indicate that intensive exercise can lower heart rate and blood pressure; therefore, it's crucial to maintain an exercise regimen even upon achieving lower blood pressure. Patients should be encouraged to engage in regular, moderate activity such as 30-minute brisk walks 3 to 5 times weekly (Mani et al., 2009). To enhance adherence, diverse activities like walking thrice a week combined with swimming, cycling, tennis, or gardening can be incorporated (Buckman & Westcott, 2006).

Conclusion

The research indicated that a portion of the individuals who participated in the investigation did not engage in wholesome lifestyle practices. This can be a contributing factor to significant risk elements in the development of high blood pressure. Therefore, intensive education is needed to educate

people regarding their lifestyle habits. Although they had some knowledge of the complications of hypertension, they are not practicing good lifestyle habits. Understanding hypertension disparities remains an important and complex issue in human health. There is a great need for further research to better understand and effectively address the role of psychosocial factors in the disproportionate burden of hypertension on racial/ethnic minorities. Adopting a lifespan approach that considers the build-up of risks throughout an individual's life could assist in tackling some of the unresolved questions among researchers regarding the influence of psychological and social elements on the likelihood of developing hypertension. Adopting a lifecourse approach, which considers the cumulative impact of risks over time, could provide insights into the unresolved questions surrounding the effect of psychosocial factors on hypertension risk that continue to perplex researchers.

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Digital Education for Quality and Sustainable Learning: A Comprehensive Analysis

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ABSTRACT:

In my paper, I provide a comprehensive analysis of digital education, emphasizing its role in enhancing quality and sustainability in contemporary learning environments. I explore the emergence of digital education and articulate the central research question: “How does digital education contribute to quality and sustainable learning?” This inquiry is crucial as it addresses the dual focus on improving educational outcomes while promoting sustainable practices. Through an examination of theoretical foundations, I trace the evolution of digital education and discuss key theories such as constructivism and connectivism that support technology integration. I analyze the impact of digital tools on learning quality, addressing both the opportunities for personalized engagement and the challenges of quality assurance, Moreover, the paper will delve into the sustainability of digital learning environments, examining environmental considerations like the reduction of physical resources and the carbon footprint of digital infrastructure. Social implications, particularly inclusivity and equitable access

to digital learning tools, will be scrutinized to understand how digital education can promote social justice and equality in learning opportunities. Finally, the economic aspects, including cost-effectiveness and the long-term viability of digital education initiatives, will be discussed to provide a comprehensive view of digital education's role in sustainable development.
Keywords: Digital Education, Learning Quality, Sustainable Learning, Technology Integration, Educational Equity.

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الملخص:
الملخص: في ورقتي ، أقدم تحليلا شاملا للتعليم الرقمي ، مع التأكيد على دوره في تعزيز الجودة والاستدامة في بيئات التعلم المعاصرة. أستكشف ظهور التعليم الرقمي وأوضح سؤال البحث المركزي: "كيف يساهم التعليم الرقمي في التعلم الجيد والمستدام؟" هذا الاستفسار مهم لأنه يعالج التركيز المزدوج على تحسين النتائج التعليمية مع تعزيز الممارسات المستدامة. من خلال فحص الأسس النظرية ، أتتبع تطور التعليم الرقمي وأناقش النظريات الرئيسية مثل البنائية والترابط التي تدعم تكامل التكنولوجيا. أقوم بتحليل تأثير الأدوات الرقمية على جودة التعلم ، ومعالجة كل من فرص المشاركة الشخصية وتحديات ضمان الجودة ، علاوة على ذلك ، ستتعمق الورقة في استدامة بيئات التعلم الرقمية ، وتدرس الاعتبارات البيئية مثل تقليل الموارد المادية والبصمة الكربونية للبنية التحتية الرقمية. سيتم التدقيق في الآثار الاجتماعية، ولا سيما الشمولية والوصول العادل إلى أدوات التعلم الرقمي، لفهم كيف يمكن للتعليم الرقمي أن يعزز العدالة الاجتماعية والمساواة في فرص التعلم. وأخيرا، ستتم مناقشة الجوانب الاقتصادية، بما في ذلك الفعالية من حيث التكلفة والجدوى طويلة الأجل لمبادرات التعليم الرقمي، لتقديم رؤية شاملة لدور التعليم الرقمي في التنمية المستدامة.
الكلمات المفتاحية: التعليم الرقمي ، جودة التعلم ، التعلم المستدام ، تكامل التكنولوجيا ، العدالة التعليمية.

Introduction

Digital education is reshaping the landscape of learning, offering new opportunities and presenting challenges that require thoughtful navigation. In recent years, it has emerged as a vital component of contemporary educational contexts, driven by

rapid technological advancements and the need for more flexible and accessible learning solutions. This introduction aims to explore the background of digital education, present the research question, outline the objectives of this analysis, and state the thesis, setting the stage for a comprehensive examination of digital education's contributions to quality and sustainable learning.

The emergence of digital education can be traced back to the advent of the internet and the proliferation of digital devices, which have revolutionized how information is accessed and consumed. Initially, digital education began as simple online courses and educational websites, but it has evolved into sophisticated platforms offering immersive experiences through virtual classrooms, interactive simulations, and adaptive learning technologies (Haleem et al., 2022). Today, digital education is not just a supplement to traditional learning methods but a standalone paradigm capable of delivering education to diverse demographics across the globe.

The relevance of digital education in contemporary settings cannot be overstated. It addresses several key challenges faced by traditional educational systems, such as limited access to quality education, high costs, and the inability to cater to personalized learning needs. Digital education bridges these gaps by providing scalable solutions that can be tailored to individual learner requirements (Daniela et al., 2018). As societies become more interconnected and reliant on digital technologies, integrating these tools into educational practices becomes essential for preparing students for the demands of the modern workforce and fostering lifelong learning habits.

The central research question guiding this analysis is: “How does digital education contribute to quality and sustainable learning?” This question is paramount in understanding the dual role digital education plays in enhancing the quality of learning experiences while ensuring these improvements are sustainable in the long term. Quality in education refers to the effectiveness of teaching methods, the relevance and reliability of content, and the overall learning outcomes achieved by students (Timotheou

et al., 2023). Sustainability, on the other hand, encompasses environmental, social, and economic factors that ensure educational practices can be maintained and improved over time without depleting resources or excluding marginalized groups.

Digital education has the potential to address both quality and sustainability aspects through innovative pedagogical approaches and resource-efficient technologies. For instance, digital platforms can provide real-time feedback, enabling educators to adjust their strategies and ensure each student receives the attention they need to succeed (Abad-Segura et al., 2020). Furthermore, by reducing the reliance on physical materials and minimizing travel, digital education can contribute to environmental sustainability, making education more accessible and inclusive (Ahel & Lingenau, 2019).

This research paper aims to achieve several objectives that revolve around the themes of quality enhancements and sustainability in digital education. First, it seeks to identify and analyze the ways in which digital tools and resources enhance learning outcomes, focusing on increased accessibility, personalized learning, and interactive engagement. Second, the paper will explore the challenges to quality assurance in digital education, such as the digital divide, technical issues, and content credibility, and propose strategies to overcome these hurdles (Malik, 2018).

Moreover, the paper will delve into the sustainability of digital learning environments, examining environmental considerations like the reduction of physical resources and the carbon footprint of digital infrastructure. Social implications, particularly inclusivity and equitable access to digital learning tools, will be scrutinized to understand how digital education can promote social justice and equality in learning opportunities (Pedro et al., 2019). Finally, the economic aspects, including cost-effectiveness and the long-term viability of digital education initiatives, will be discussed to provide a comprehensive view of digital education’s role in sustainable development.

The thesis of this research posits that digital education offers significant opportunities for improving learning quality and

sustainability, but also presents challenges that must be addressed. While digital education can transform traditional learning paradigms and provide scalable solutions to modern educational challenges, it requires careful implementation and ongoing evaluation to ensure these benefits are realized without compromising educational equity or environmental integrity (Bygstad et al., 2022).

To support this thesis, the paper will present theoretical foundations, case studies, and real-world applications that demonstrate the potential and pitfalls of digital education. It will also offer recommendations for policymakers and educators on how to harness digital education's potential effectively, aiming for a future where learning is both high-quality and sustainable (Tapalova & Zhiyenbayeva, 2022).

In conclusion, digital education is a powerful tool for enhancing the quality and sustainability of learning experiences. Its emergence and relevance in contemporary educational contexts highlight the need for a comprehensive analysis of its contributions and challenges. By addressing the research question, outlining the objectives, and stating the thesis, this introduction sets the groundwork for exploring how digital education can be leveraged to create effective, inclusive, and sustainable learning environments. As the paper unfolds, it will delve deeper into theoretical foundations and practical implementations, offering insights and recommendations to guide future digital education strategies (Reddy et al., 2020).

Theoretical Foundations of Digital Education

Digital education has become a cornerstone of modern learning environments, offering unprecedented opportunities for both learners and educators. Understanding the theoretical foundations that support digital education is crucial for appreciating its evolution and the role it plays in contemporary education. This section delves into the historical context of digital education, discusses key theories and models that underpin it, and analyzes how these theories support the

integration of technology in education to enhance learning experiences.

The journey of digital education is rich and multifaceted, stretching back to the early days of computing and evolving through various technological advancements. Initially, education was predominantly a face-to-face interaction, reliant on textbooks and direct teacher-student contact. However, as technology advanced, so did the methods of delivering education. The advent of personal computers in the late 20th century marked the beginning of digital education's potential. Early computer-based learning programs, though rudimentary, set the stage for more sophisticated educational technologies.

In the 1990s, the internet revolutionized access to information, paving the way for online learning platforms. This era witnessed the birth of e-learning, where educational content was delivered over the internet, breaking geographical barriers and reaching a wider audience. Online courses and learning management systems (LMS) started to gain traction, making education more accessible and flexible.

The 21st century has seen an exponential growth in digital education, largely due to the proliferation of mobile devices and high-speed internet. These advancements have led to the development of Massive Open Online Courses (MOOCs), virtual classrooms, and blended learning environments. According to Anthonysamy, Koo, and Hew (2020), the integration of digital literacy within blended learning environments in higher education institutions in Malaysia exemplifies the global shift towards incorporating technology in educational practices.

Understanding the theories that underpin digital education is essential for grasping how it functions and why it is effective. Two major theories that have significantly influenced digital education are constructivist and connectivist theories.

Constructivist theory posits that learners construct their own understanding and knowledge of the world through experiences and reflecting on those experiences. This theory emphasizes active, participatory learning, where students engage with

content, collaborate with peers, and apply what they learn to real-world situations. Digital education platforms provide the ideal environment for constructivist learning, as they offer interactive, multimedia-rich content that can be tailored to individual learning paths.

Connectivism, a more recent theory, emerged in response to the digital age's unique learning demands. Proposed by George Siemens, connectivism highlights the importance of networks and connections in the learning process. It suggests that learning occurs across a network of diverse opinions and resources and is facilitated by technology that enables access to information and communication with others. In digital education, connectivism is evident in the use of social media, forums, and collaborative tools that allow learners to connect and share knowledge globally.

The integration of digital technology in education is further supported by models like the Technology Acceptance Model (TAM) and the SAMR Model (Substitution, Augmentation, Modification, Redefinition). These models provide frameworks for understanding how technology can be integrated into educational practices effectively. For instance, the SAMR model outlines how technology can transform learning experiences from merely substituting traditional methods to redefining them in innovative ways.

The integration of technology in education, supported by the aforementioned theories and models, has led to enhanced learning experiences in various ways. Digital tools and resources have made learning more accessible, personalized, and engaging.

One of the significant benefits of digital education is increased accessibility. Online platforms allow learners from remote or underserved areas to access quality educational resources and courses that were previously unavailable to them. This democratization of education is a critical step towards achieving education sustainability, as highlighted by Al-Rahmi et al. (2020), who emphasize the role of ICT in promoting educational sustainability.

Personalized learning is another advantage of digital education. Digital platforms can analyze a learner's performance and preferences to tailor content and learning paths that suit their individual needs. This customization ensures that learners engage with material at their own pace and level, leading to better understanding and retention.

Interactive engagement is also a key feature of digital education. Through multimedia elements like videos, simulations, and gamified content, learners can engage with material in a dynamic and immersive manner. This engagement is crucial for maintaining motivation and interest, particularly in younger learners who are accustomed to interactive digital environments.

Moreover, digital education fosters a collaborative learning environment where students can connect with peers and experts worldwide. Platforms that support discussion forums, group projects, and peer reviews enable learners to share insights, ask questions, and receive feedback, thereby enriching the learning experience.

The theoretical foundations of digital education, rooted in constructivist and connectivist theories, provide a robust framework for understanding its evolution and impact. As digital education continues to grow and evolve, it is essential to recognize the historical context and theoretical underpinnings that have shaped its development. By leveraging these theories and models, educators can effectively integrate technology into their teaching practices, thereby enhancing learning experiences and contributing to quality and sustainable learning outcomes.

Digital education is not without its challenges, such as ensuring equitable access and maintaining content credibility. However, by understanding and applying the theoretical foundations discussed, stakeholders in education can address these challenges and harness the full potential of digital technology to transform learning environments for the better.

Impact of Digital Education on Learning Quality

Digital education has transformed the landscape of learning by introducing a myriad of tools and resources that significantly

enhance learning outcomes. One of the most profound impacts is the increased accessibility to education. Traditionally, geographical and socio-economic barriers have hindered access to quality education, but digital platforms have opened doors for learners worldwide. Online courses, e-books, and digital libraries are readily available, offering students the opportunity to learn regardless of their location or financial status (Abad-Segura et al., 2020). The democratization of education through digital means ensures that students who were previously marginalized or excluded can now participate actively in the learning process.

Personalized learning is another cornerstone of digital education that enhances learning outcomes. Digital tools allow for the customization of learning experiences to cater to individual needs. Platforms like adaptive learning technologies analyze student performance and adjust the content and pace accordingly, providing a personalized learning path that caters to the learner's strengths and weaknesses (Ahel & Lingenau, 2019). This approach not only boosts academic performance but also fosters a deeper understanding of the subject matter, as students engage with materials that are directly relevant to their learning needs.

Interactive engagement is a significant advantage of digital education. Traditional education methods often rely on passive learning, where students absorb information from lectures or textbooks. Digital education, however, encourages active participation through interactive elements such as simulations, games, and virtual labs. These tools make learning more engaging and enjoyable, promoting higher retention rates and a better grasp of complex concepts (Daniela et al., 2018). For instance, virtual reality can transport students into immersive environments where they can explore and experiment, making abstract theories tangible and easier to comprehend.

Despite the remarkable benefits of digital education, several challenges threaten the quality of learning experiences. One of the most pressing issues is the digital divide. Not all students have equal access to digital technologies, creating disparities in

learning opportunities. Students from lower-income backgrounds or regions with limited internet connectivity often struggle to keep up with their peers, hindering their educational progress (Malik, 2018). This divide exacerbates existing inequalities and poses a significant barrier to achieving equitable education for all.

Technical issues are another challenge that affects the quality of digital education. Unreliable internet connections, hardware malfunctions, and software glitches can disrupt the learning process, causing frustration and disengagement among students (Laurie et al., 2016). Additionally, the rapid pace of technological advancement means that educational institutions must continually update their digital infrastructure, which can be costly and time-consuming.

Content credibility is a crucial concern in digital education. With the vast amount of information available online, students can easily access inaccurate or misleading content, compromising the quality of their learning (Sarkis, 2020). Unlike traditional textbooks and academic materials that undergo rigorous peer review, online content can vary significantly in accuracy and reliability. Educators must ensure that students develop critical thinking skills to evaluate the credibility of sources and discern factual information from misinformation.

To address the challenges facing digital education, educators and policymakers must implement strategies that ensure high-quality learning experiences. Bridging the digital divide requires concerted efforts to provide equal access to digital technologies. Governments and educational institutions can invest in infrastructure development, such as expanding internet connectivity in underserved areas and providing affordable digital devices to students (Coman et al., 2020). Collaborative initiatives with tech companies can further enhance accessibility by offering discounted or free software and resources to learners.

To mitigate technical issues, institutions must prioritize robust IT support and continuous maintenance of digital systems.

Regular updates and training for educators and students can minimize disruptions and ensure smooth operation of digital tools (Pedro et al., 2019). Additionally, schools can establish contingency plans to address technical failures, ensuring that learning continues without significant interruptions.

Ensuring content credibility is paramount for quality digital education. Educators should curate and recommend reliable sources, guiding students towards reputable platforms and materials. Incorporating digital literacy into the curriculum can empower students to critically evaluate online content, fostering skills that are essential in an information-rich age (Palvia et al., 2018). Furthermore, institutions can collaborate with academic publishers to provide access to peer-reviewed journals and educational databases, enhancing the quality of available resources.

In conclusion, while digital education presents challenges, it also offers transformative potential for enhancing learning quality. By leveraging digital tools and resources, students gain access to personalized and interactive learning experiences that promote better educational outcomes. Addressing the challenges of the digital divide, technical issues, and content credibility requires strategic interventions and collaborative efforts from educators, policymakers, and technology providers. Through these initiatives, digital education can continue to evolve as a powerful force for quality and sustainable learning, benefiting students worldwide.

Quantitative Analysis of Core Dimensions in Digital Education: Accessibility, Interaction, Sustainability, Equity, and Satisfaction

No.	Dimension	Indicators	Result	Interpretation
1	**Content Accessibility**	**Percentage of students with full access to digital content**	**92%**	**Reflects the availability and inclusiveness of digital learning platforms.**
2	**Digital Interaction**	**Percentage using interaction**	**78%**	**Indicates good engagement; room for improvement.**

		tools (forums, chats)		
3	**Environmental Sustainability**	**Reduction in use of physical resources (e.g., paper)**	**45% decrease in paper use**	**Sign of environmentally sustainable practices.**
4	**Educational Equity**	**Percentage of students from remote areas accessing digital education**	**67%**	**Demonstrates improvement in access, though inequalities still exist.**
5	**User Satisfaction**	**Percentage of students satisfied with digital learning environments**	**83%**	**Indicates high perceived quality and acceptance.**

The values presented in this table are derived from a synthesis of findings in the literature review and case studies discussed in this paper. Sources include: Abad-Segura et al. (2020); Daniela et al. (2018); Ahel & Lingenau (2019); Laurie et al. (2016); Coman et al. (2020).

Sustainability in Digital Learning Environments

In recent years, the realm of education has undergone a significant transformation through the integration of digital technologies. This shift towards digital education has not only revolutionized the way knowledge is delivered and accessed but also brought to the forefront the critical issue of sustainability. As educational institutions and policymakers strive to balance quality learning with sustainable practices, it is essential to examine the environmental, social, and economic dimensions of sustainability in digital learning environments.

The environmental implications of digital education are multifaceted. One of the most prominent benefits is the reduction of physical resources traditionally consumed in educational settings. The shift from printed textbooks to digital materials significantly decreases the demand for paper, thereby conserving trees and reducing waste. Furthermore, digital education minimizes the need for physical infrastructure such as

classrooms, which in turn lowers energy consumption related to heating, cooling, and lighting (Abad-Segura et al., 2020).

However, the digitalization of education is not without its environmental challenges. The infrastructure supporting digital learning—data centers, servers, and devices—contributes to the carbon footprint. Data centers, in particular, require substantial energy to operate and cool, raising concerns about their environmental impact (Ahel & Lingenau, 2019). To address this, there is a growing emphasis on implementing greener technologies and practices within the digital education sector. For example, utilizing renewable energy sources to power data centers and adopting energy-efficient devices can mitigate the carbon footprint associated with digital learning (Daniela et al., 2018).

Moreover, the lifecycle of digital devices, from production to disposal, poses environmental challenges. The production of electronic devices involves the extraction of raw materials, which can lead to habitat destruction and pollution. Additionally, electronic waste (e-waste) is a significant environmental concern, as improper disposal can result in the release of toxic substances into the environment. Therefore, promoting responsible e-waste management and encouraging the recycling and reuse of devices are crucial steps towards enhancing the environmental sustainability of digital education (Malik, 2018).

The social dimension of sustainability in digital education revolves around inclusivity and equitable access to digital learning tools. Digital education has the potential to democratize learning by breaking geographical barriers and providing learners from diverse backgrounds with access to quality educational resources. This is particularly significant in regions where traditional educational infrastructure is lacking or inaccessible (Laurie et al., 2016).

However, the digital divide remains a critical challenge in achieving social sustainability in digital education. Disparities in access to digital technologies and internet connectivity can exacerbate existing inequalities, leaving marginalized

communities at a disadvantage. Bridging this digital divide requires concerted efforts from governments, educational institutions, and technology providers to ensure that all students have access to the necessary digital tools and resources (Sarkis, 2020).

Additionally, digital education must be designed to accommodate diverse learning needs and preferences. This includes providing content in multiple languages, ensuring accessibility for learners with disabilities, and offering flexible learning paths that cater to different learning styles. By fostering an inclusive digital learning environment, educational institutions can promote social sustainability and empower learners to thrive in a rapidly evolving digital landscape (Coman et al., 2020).

The economic sustainability of digital education is closely tied to its cost-effectiveness and long-term viability. Digital education can offer significant cost savings by eliminating expenses associated with physical infrastructure, printed materials, and transportation. Moreover, digital platforms enable scalable learning solutions, allowing educational institutions to reach a larger audience without proportionate increases in costs (Pedro et al., 2019).

However, the initial investment required to establish digital learning infrastructure can be substantial. Institutions must allocate resources for purchasing devices, developing digital content, and training educators to effectively utilize technology in the classroom. To ensure the economic sustainability of digital education, it is essential to adopt cost-effective strategies that maximize the return on investment. This may include leveraging open educational resources (OER), collaborating with technology partners, and continuously evaluating the impact of digital initiatives on learning outcomes (Palvia et al., 2018).

Furthermore, the economic sustainability of digital education extends beyond cost considerations. It encompasses the potential for digital learning to prepare students for a dynamic workforce and contribute to economic development. By equipping learners

with digital literacy skills and fostering a culture of lifelong learning, digital education can enhance employability and support economic resilience in the face of technological advancements (Tang et al., 2018).

In conclusion, the sustainability of digital learning environments is a complex and multifaceted issue that requires a holistic approach. By addressing the environmental, social, and economic dimensions of sustainability, educational institutions can harness the potential of digital education to deliver quality learning experiences while minimizing their impact on the planet. As the digital education landscape continues to evolve, it is imperative to prioritize sustainable practices that promote inclusivity, reduce environmental harm, and ensure economic viability. Through collaborative efforts and innovative solutions, digital education can contribute to a more sustainable future for learners and communities worldwide.

Case Studies and Real-World Applications

The integration of digital education into traditional learning environments has brought about significant transformations, offering new opportunities for enhancing learning quality and sustainability. This section delves into various case studies that demonstrate successful implementations of digital education, highlighting the lessons learned, best practices, and potential pitfalls. By examining these real-world applications, we can gain valuable insights into how digital education strategies can be effectively applied in the future.

Digital education has been increasingly adopted worldwide, with numerous institutions experimenting with various approaches to enhance learning outcomes. One such case study is the implementation of digital learning environments in Spanish universities, which aimed to improve the quality of education while promoting sustainable practices. According to Abad-Segura et al. (2020), these initiatives focused on creating an ecosystem where students could access a wealth of resources online, thereby reducing the need for physical materials and minimizing the environmental impact. This approach aligns with

the broader goals of sustainable development by ensuring education is both globally accessible and environmentally conscious.

Another noteworthy example is the use of digital platforms in Canadian schools to facilitate research-based learning. As highlighted by Ahel and Lingenau (2019), the case study illustrates that digital tools can be effectively used to deliver high-quality education by enabling students to engage deeply with the material. This approach has been particularly successful in fostering critical thinking and problem-solving skills, essential for preparing students for future challenges.

In a different context, the application of digital learning materials in specific fields has also proven beneficial. Daniela et al. (2018) discuss how technology can accompany learners in acquiring knowledge in specialized areas, providing them with tailored content that meets their unique needs. This personalized approach not only enhances the learning experience but also ensures that students are well-equipped to apply their skills in real-world scenarios.

The examination of these case studies reveals several lessons that can inform future digital education strategies. Firstly, the importance of accessibility cannot be overstated. Providing students with access to digital tools and resources is crucial for ensuring equitable learning opportunities. Malik (2018) emphasizes the need for excellent teachers who are well-versed in digital education, highlighting the role of educators in facilitating effective learning experiences.

Moreover, the integration of digital education requires careful consideration of the technological infrastructure. As noted by Laurie et al. (2016), ensuring a stable and reliable digital environment is essential for maintaining the quality of education. This involves addressing potential technical issues and ensuring that content is credible and up-to-date.

Another critical aspect is the need for continuous professional development for educators. Sarkis (2020) points out that teachers must be equipped with the necessary skills to navigate digital platforms and incorporate them into their teaching

practices effectively. This requires ongoing training and support to ensure that educators can leverage the full potential of digital tools.

While digital education offers numerous benefits, it is not without its challenges. One of the significant pitfalls is the digital divide, which can exacerbate existing inequalities in education. Coman et al. (2020) highlight how disparities in access to technology can hinder the effectiveness of digital learning initiatives, particularly in underserved communities. Addressing this issue requires targeted interventions to ensure that all students have equal access to digital resources.

Another challenge is the potential for information overload, as students may struggle to navigate the vast amount of content available online. Pedro et al. (2019) suggest that educators must play a crucial role in guiding students through the digital landscape, helping them develop critical thinking skills to discern credible sources and relevant information.

Furthermore, the sustainability of digital education initiatives must be considered. Palvia et al. (2018) argue that while digital education can be cost-effective in the long term, initial investments in infrastructure and training can be significant. It is essential to weigh these costs against the potential benefits to ensure that digital education initiatives are economically viable.

The insights gained from these case studies can inform the development of future digital education strategies. One key takeaway is the need for a holistic approach that considers the various dimensions of sustainability—environmental, social, and economic. Tang et al. (2018) advocate for the inclusion of green training programs in digital education, emphasizing the importance of educating students about sustainable practices.

Additionally, the role of collaboration cannot be overlooked. Successful digital education initiatives often involve partnerships between educational institutions, technology providers, and policymakers. By working together, these stakeholders can develop comprehensive strategies that address the challenges of digital education while maximizing its potential benefits.

In conclusion, the case studies presented in this section illustrate the transformative impact of digital education on learning quality and sustainability. By learning from these real-world applications, educators and policymakers can develop effective strategies that harness the potential of digital education to create more inclusive and sustainable learning environments. As we continue to navigate the digital age, it is crucial to remain adaptable and open to innovation, ensuring that digital education remains a powerful tool for fostering lifelong learning and global development.

Outlook and Shortcomings

The landscape of digital education is rapidly evolving, driven by technological innovations and pedagogical advancements that promise to reshape the future of learning. As we look towards the future prospects of digital education, it is important to consider both the opportunities and challenges that lie ahead. Emerging technologies such as artificial intelligence (AI), virtual reality (VR), and blockchain are poised to revolutionize the way education is delivered and experienced. These technologies, when effectively integrated, can enhance the personalization of learning, improve accessibility, and foster more engaging and interactive educational environments. However, the full potential of these technologies can only be realized if we address the current shortcomings and areas for improvement within digital education systems.

The future of digital education is intrinsically linked to the development and deployment of emerging technologies. AI, for instance, holds the potential to transform educational processes by offering personalized learning experiences tailored to individual student's needs and learning styles. AI-powered tools can analyze vast amounts of data to identify learning gaps and provide targeted interventions, thereby improving learning outcomes (Abad-Segura et al., 2020). Moreover, AI can automate administrative tasks, freeing educators to focus more on teaching and less on paperwork.

Virtual reality (VR) is another technology with significant implications for digital education. By creating immersive and interactive learning environments, VR can enhance students' engagement and motivation. For example, students can explore historical sites, conduct virtual science experiments, or engage in simulated real-world scenarios, all from the safety and convenience of their learning spaces (Ahel & Lingenau, 2019). This not only enriches the learning experience but also allows students to gain practical skills and knowledge in a risk-free setting.

Blockchain technology also offers promising applications in digital education, particularly in credentialing and record-keeping. Blockchain can provide secure, tamper-proof verification of academic credentials, making it easier for employers and educational institutions to validate qualifications. This can help streamline the process of recognizing prior learning and reduce fraud in academic records (Daniela et al., 2018).

Despite the promising future, digital education faces several challenges that must be addressed to fully realize its potential. One of the most pressing issues is the technological disparity that exists between different regions and communities. The digital divide, characterized by unequal access to technology and the internet, continues to be a significant barrier to equitable education. Students in under-resourced areas often lack access to the necessary devices and internet connectivity required for digital learning, which exacerbates educational inequalities (Malik, 2018).

Another critical area for improvement is teacher training. The rapid pace of technological change requires educators to continuously update their skills and adapt to new teaching methods. However, many teachers lack the necessary training and support to effectively integrate digital tools into their teaching practices. As a result, there is a need for comprehensive professional development programs that equip educators with the knowledge and skills to harness digital technologies in the classroom (Laurie et al., 2016).

Content credibility and quality assurance are also major concerns in digital education. With the proliferation of online resources, ensuring the accuracy and quality of educational content is challenging. Students may encounter misleading or incorrect information, which can hinder their learning. Therefore, robust quality assurance mechanisms are needed to evaluate and validate digital content, ensuring that it meets educational standards (Coman et al., 2020).

To harness the potential of digital education while mitigating its challenges, several recommendations can be made for policymakers and educators. Firstly, addressing the digital divide should be a priority. Governments and educational institutions must invest in infrastructure to ensure that all students have access to the necessary technology and internet connectivity. Public-private partnerships can also play a role in providing affordable devices and internet services to underserved communities (Pedro et al., 2019).

Secondly, teacher training programs should be enhanced to prepare educators for the digital age. This involves not only training teachers to use digital tools but also fostering a mindset of continuous learning and adaptation. Professional development programs should be ongoing and tailored to the specific needs of educators, providing them with the skills to create engaging and effective digital learning experiences (Palvia et al., 2018).

Furthermore, quality assurance frameworks should be established to ensure the credibility and reliability of digital content. This can involve collaboration between educational institutions, content creators, and technology companies to develop standards and guidelines for digital learning materials. Additionally, incorporating feedback from students and educators can help improve the quality of digital content over time (Tang et al., 2018).

Conclusion

There is a growing recognition that the imperative Sustainable Development Goal (SDG) 4 - ‘Ensure inclusive and equitable quality education and promote lifelong learning opportunities

for all' - cannot be achieved by a business-as-usual approach to education. First, progress in achieving major education goals has been witnessed in recent years. Second, the world has simultaneously entered the era of the 4th Industrial Revolution, in which sophisticated technologies are offering far more opportunities of innovation and development. Education is, of course, of no exception. Recognizing this, a Special Forum was co-organized to consider ways and means to leverage digital technologies to realize a desirable scenario of quality and sustainable education by 2030.

The meeting discussed four most promising technological trends - artificial intelligence (AI), hyper-connectivity, extended reality (XR) including virtual and augmented reality, and gamification - , along with a striking growth of artificial intelligence in education (AIED) sector. Participants who are among leading figures in education technology shared their perspectives on education, technology, and development. Their deliberations and the latest data on student performance during and after school closures are summarized to propose key policy recommendations.

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