THE IMPACT OF THE DIGITAL REVOLUTION
ON FUTURE FIGHTER PILOT TRAINING

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The Digital Revolution shall profoundly transform the landscape of future fighter pilot training, integrating advanced technologies to enhance efficiency, realism, and adaptability. Key innovations include virtual and augmented reality, big data analytics, an understanding of cortex development from a young age, the application of the athlete model, and a marked shift from legacy approaches to tech training methodologies. Legacy training approaches primarily relied on traditional classroom instruction, manual flight simulations, and live flight exercises. While effective, these methods are resource-intensive, costly, and limited in their ability to replicate the complexities of modern aerial combat. Pilots trained under these conventional systems often face constraints in terms of exposure to diverse combat scenarios and adaptive learning opportunities. In contrast, tech training approach leverages virtual and augmented reality to create immersive, realistic simulation environments that can replicate a vast array of combat situations with high fidelity, fostering a more challenging and realistic training experience. This approach can offer personalized training programs by identifying individual strengths and weaknesses through continuous performance monitoring. Understanding cortex development, particularly in young individuals, plays a critical role in shaping effective training methodologies. The cortex, responsible for critical functions such as decision-making, and attention, undergoes significant development during childhood and adolescence. Early engagement in activities that stimulate cognitive functions can enhance the cortex's growth and plasticity, preparing individuals for advanced training later in life. The athlete model further revolutionizes pilot training by treating pilots as elite athletes. This model emphasizes comprehensive physical conditioning, mental resilience, and optimized nutrition to enhance overall performance. Incorporating principles from sports science, it ensures that pilots maintain peak physical and cognitive conditions, enabling them to endure the high demands of aerial combat. Big data analytics further contribute by aggregating vast amounts of flight data to refine training syllabi and predict potential skill gaps. These technologies not only reduce the costs and logistical constraints associated with conventional training but also ensure a higher standard of preparedness for pilots facing modern combat environments. Next generation training should continually evolve and optimize fighter pilot training, ensuring that future fighters

are better equipped with the skills and knowledge necessary to meet the demands of contemporary and future aerial warfare.

Key words: *virtual and augmented reality, big data analytics, cortex development, aerial warfare, professional athlete.*

1. INTRODUCTION

The military relies on manpower as the essential resource. Only with high-quality and motivated individuals can budgets and weapon systems be transformed into the effective military capabilities that are required to provide for a nation's security. Managing it, and managing it well— getting the right people into the right jobs at the right time and motivating them to work hard and intelligently—is therefore the essence of military success. But, as with any situation that involves human motivation, especially in the peculiar circumstances of military life, this is a management challenge of considerable complexity [1].

The challenge to the modern defence institution at present is to provide a new balance between the task of the armed forces and the means available in order to create affordable armed forces with sufficient room for operations and capital investments [2].

This paper should address one of the main Human Resources Management objectives, „Improving employee performance" by applying the system's perspective in approaching change management in defense education institutions and analysing the best practices in fighter pilot training and identifying defence organization's drivers and enablers for managing personnel motivation and performance.

2. EDUCATION TECHNOLOGY EVOLUTION

Digital revolution is considered the third industrial revolution in the human kind and, easy to be consider, the most complex and innovative, defined as the rise of electronics. Digital revolution changed the analog mechanical and electronic technology to digital technology, marking the beginning of what we refer to as the „Information Age".

Etymology. The word "digital" comes from Latin - digitus, finger - and refers to one of the oldest tools for counting. When information is stored, transmitted or forwarded in digital format, it is converted into numbers - at the most basic machine-level as "zeroes and ones" [3].

Starting with fourth computer generation, Microprocessor based, in the 80's, high developed countries as

USA started to implement the new technologies in the education system being sure that the technology will play a key role in the reform and will improve the performance. Computers and network-based technology has been used to tailor learning experience to learner needs and provide students with easier access to resources outside the school, enriching their opportunities and learning experience.

As technology became more user-friendly, people became more digitally literate and started using technology in new ways and in increasingly diverse areas of their lives. The functioning of our everyday lives has been largely reshaped by technology. The effectiveness of shared resources can be maximized and individual users can receive reliable solutions through these new systems. Despite being designed to facilitate multiple aspects of our lives, users themselves have begun to play an active role in creating technology.

Instructors can tailor learning experiences to each student's learning style, preferences, and pace using digital technologies. This has made learning more engaging and effective, as students can learn at their own pace and in their preferred way.

For our study, I will take in consideration two aspects: Medical Cortex Development and the most important Technology Evolution Events from the third millennium having in mind that by 2020, more than half of the world's population were active internet users.

The next paragraphs give a brief overview of the key points and crucial moments in the evolution of education technology.

A big shift in education system started in the early 2000 when the Broadband was introduced in many countries providing much faster internet access. The digital revolution became truly global during that time, with digital technologies spreading to the developing world. In the same period, more than 94% of US schools had internet access in their classrooms, as an example. In 2007, when the iPhone was released, it was considered a game-changer in technology and has had a profound impact on society and culture. The first iPhone transformed the way people learn, communicate, work, and entertain themselves becoming an indispensable part of modern life. In 2004, Facebook was born and a new age of social media began. Instant connectivity has evolved from being a tool for personal communication to a platform for educational instruction and outreach. In 2005 YouTube launches with a video which has garnered almost 40 million views. In 2010, the first iPad computers were released, which

provided a more convenient and easy way to access desired information on a bigger screen. Google introduced a new education platform called Google Classroom in 2014. The new platform had many benefits. It made it easy to create classes, distribute assignments, stay organized, and last but not least, saved time and paper. Oculus Rift, the virtual reality headset, was made available to the public in 2016. Starting from 2018, Kitaboo AR has transformed paper books into interactive eBooks, symbolizing a new era in digital education. The creation of forecasts for the future is made possible by predictive learning analytics in 2019, software that analyses past trends in learning experiences. During the Covid pandemic in 2020, many EdTech apps were released and lots of virtual meeting apps gained increased popularity. While 2024 AI appears to be a significant advancement in technology, I decided to ignore it for this paper.

Students who were born in early 2000 will or will commence their pilot training in 2024. The trainees' needs should be taken into account when changing the approach to their training programs, as quick as possible, to keep up the system needs with the speed of out changing security environment.

3. PROFESSIONAL ATHLETE VS. FORMAL MILITARY TRAINING

3.1. The lost decade

The early years of a child's life play a crucial role in their future health and development. The rapid growth of the brain, starting before birth and continuing into early childhood, is one of the main reasons. Although the brain continues to develop and change throughout adulthood, the first 5 years can lay the foundation for future learning, health, and life success. The brain's development is heavily influenced by the child's experiences with others and the world, as well as technology.

In the last 20 years, unprecedented progress has been made in understanding how the brain develops. By age 3, children's brains will be approximately 80% of their adult size The brain has twice as many synapses as it will have in adulthood at age 2 or 3. After the age of 5, these brain connections progressively decreased through a process called pruning. The process of building synapses continues until 11 or 12 years old, which is then followed by another pruning process after 17 or 18 years old. This aids in the efficiency of young children's brain circuits. The average baby's brain size at birth is approximately equal to one-fourth the size of an

average adult brain. It is amazing how the brain it doubles in size in the first year then keeps growing at around 80% of adult size by the age of 3 and 90% by age 5.

During these early years, the connections required for significant, higher-level abilities like motivation, self-regulation, problem-solving, and communication are formed or absent altogether. The formation of crucial brain connections later in life is much more challenging. It is well known that when you are young the brain is most flexible and adaptable to learning. The brain's ability to reorganize and adapt to new or unexpected challenges decreases as it matures.

The human brain's maturation is remarkably prolonged and characterized by ongoing dynamic changes throughout the lifespan [4].

Recent technological advances resulted in the differentiation of cortical volume into two underlying components, cortical thickness and cortical surface area. Cortical thickness in the majority of brain regions demonstrates linear monotonic decline occurring mostly similarly for boys and girls between the ages of 4.9 and 22 years, with the peak of cortical thickness manifesting no later than age 8 years [5]. Your capacity to understand the link between your actions and potential short- or long-term consequences is considered complete once your prefrontal cortex has matured, which typically occurs at the age of 25.

The human brain is undoubtedly the most complex biological system, with various functionally distinct regions, structures, neural circuits, and cell types. It has a lifespan that is highly dynamic, resulting in continuity and changes at both structural and functional levels. Comparing the brain to the rest of the body, its developmental trajectory is unique.

Research has shown that people become interested in flying at an early age, usually around age 12, but there is typically no formal military training until the age of 22. According to specialists, students today begin their military flight training with 1,000-1,500 hours of under instruction, just like professional athletes. By starting training early, individuals are able to develop fundamental skills, techniques, and physical attributes during critical periods of growth and development. The extended training window afforded by starting at a young age can facilitates gradual progress through various stages of skill acquisition, allowing individuals to tailor their learning pace and potentially achieve important skills before entering a formal military training. Furthermore, early starters may have the chance to acquire invaluable

experience and exposure to high-level aviation practices.

Moreover, beginning training later in life may lead to time constraints, as people may have to balance their training obligations with other obligations like family or education. In order to catch up with colleagues who started training earlier, it may take intense dedication, focused effort, and possibly longer training hours to bridge the gap in skill level and experience.

3.2. Professional athlete

Professional athlete: starts as early as 3 years old. Mission: score a three-point field goal.

Optimizing physical performance, mental resilience, and overall well-being is the aim of professional athlete training, which is a rigorous and multifaceted process. A holistic approach is required for professional athlete training that addresses the physical, mental, and emotional aspects of performance. The use of this approach aids athletes in achieving their full potential and success in their respective sports. It is common for this training to start at the age of two or three years old.

Coby Bryant started playing basketball when he was three, and the Lakers were his favourite team when he was growing up. When he was six, his father retired from the NBA and moved his family to Rieti in Italy to continue playing professional basketball. Coby began to play basketball seriously while living in Reggio Emilia. His grandfather mailed him videos of NBA games for him to study. From 1987 to 1989, his father played for Olimpia Basket Pistoia. Kobe worked at the games as a ball and mop boy and practiced shooting at halftime. "At every one of our games at halftime, it was the Kobe show. He'd get out there and get his shot up. We'd come out of the locker room at halftime and have to chase him off the court" [6].

„If you want to be a better player, you have to prepare, prepare, and prepare some more" [7].

3.3. Formal military training

Pilot Training starts at 22 years old. Mission: defense of the country. Fly a multi-million Dollar aircraft.

Formal military training is a comprehensive and structured process in three phases, designed to equip aspiring pilots with the knowledge, skills, and knowledge necessary to operate military aircraft safely and effectively. An accredited management curriculum, an intense leadership environment, a comprehensive peer-driven character development program, and rigorous physical training are all part of the process of pushing and challenging students' knowledge and intellect.

They are experiencing the freedom and discipline of flight for the first time in their career. The initial phase of pilot training concentrates on developing fundamental flying skills and aviation knowledge. Classroom instruction that covers topics like aerodynamics, aircraft systems, navigation, and flight regulations is typically the starting point for students. To develop basic piloting skills including aircraft control, takeoffs, landings, and basic maneuvers without the use of flight simulators, they then move onto introductory flight lessons in small propeller-driven aircraft.

Upon graduation from the Air Force Academy, graduates are awarded a Bachelor of Management degree and a commission as a second lieutenant. They proceed with their education and training as a pilot during the second phase of their training. Moving to more advanced training aircraft, like turboprop-powered aircraft or jet trainers. Flight lessons, simulator sessions, and academic coursework are used to continue developing their flying skills. The focus is on learning how to handle an airplane, fly instrument, navigate safely, handle emergency procedures, and perform basic aerobatics. The start of this phase is usually delayed by at least a year after graduation.

Last but not least, depending on their career path and aircraft assignment, the advanced flight training phase focuses on preparing trainees for the specific demands of military aviation with an unique training curriculum and requirements tailored to the specific mission and aircraft type. High-performance jet aircraft training can involve receiving instruction for advanced aerobatics, formation flying, tactical maneuvers, air combat techniques, and mission-specific procedures. Pilot preparation for operational missions may involve training exercises that simulate real-world combat scenarios and mission profiles.

4. LEGACY TRAINING APPROACH VS. TECH TRAINING APPROACH

Technology has always been at the forefront of human education. Nowadays most students are equipped with several portable technological devices at any given time and technology continues to push educational capabilities to new levels being evident now more than ever the importance technology in training [8].

Military theorists and scholars throughout history have noted the occurrence of profound, discontinuous changes in the conduct, sometimes even the nature, of warfare. Recently, significant intellectual effort has focused on

such an emerging technical revolution in military, brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and operational and organizational concepts, fundamentally alters the character and conduct of military operations. Given this fact, consideration of the future focus and conduct of professional military education can be counted among the most vital tasks [9].

Nowadays with the help of digital technologies instructors use simulations, gamification, and virtual reality to make learning more interactive and engaging. To connect with students and create collaborative learning environments, they can use social media and other online platforms.

4.1. Legacy approach

Lectures, textbooks, and standardized assessments are commonly used in legacy training, which is characterized by traditional methods of instruction that have been used for years. Although these methods have been effective in some instances, they may not fully capitalize on the opportunities offered by technological advancements. Passive learning is promoted by the legacy training approach, where students are expected to receive information and not actively engage in it. Students' opportunities to improve situational awareness, problem-solving, and decision-making may be impeded by this passive approach to learning. Moreover, it can hinder student engagement and motivation.

In flight training the main focus was to build specific skillset to pass check ride then focus on next skill/check ride where previous skillset begins to deteriorate because of lack of repetition to build habits. The lack of situational variability in this approach prevents building mastery, and also prevents skill development together.

By using this method, all trainees/students can attain a basic level of flight proficiency within the same time /events.

4.2. Tech Training App

Technology is used in tech training to enhance learning experiences by integrating digital resources, interactive tools, and online platforms to deliver instruction and support skill development. The use of adaptive learning technologies and personalized learning pathways enables tech training to tailor instruction to each learner's needs, preferences, and learning styles. Furthermore, it embraces hybrid learning modalities, which consist of online learning, face-to-face instruction, virtual classrooms, and

self-paced modules to offer flexible and accessible learning experiences. The focus of tech training is on applying learning to real-world situations, solving real-world combat scenarios, real-life inflight situations, and developing practical skills relevant for operational missions through a competency-based approach.

The main aim of flight training is to acquire the necessary skills to become qualified to fly multiple mission-based events. Using the competency-based approach results in a slower improvement in individual skill proficiency, but cultivates habits through more repetitions. Build mastery via situational variety. The skillsets are combined or integrated into a larger objective to enhance situational awareness and decision-making.

The goal of this approach is to achieve the mission proficiency level for all graduates, but it requires a variety of events/times.

4.3. Directions for tech training approaches
4.3.1. Remote Simulator instruction is an imperative

Implementing a competency-based approach can be made easier with remote simulator instruction. Trainees can practice their skills and demonstrate their understanding in a controlled environment using simulators to engage in hands-on

learning experiences. Meaningful skill development can be achieved through a simulator that closely simulates real-life scenarios. Providing guided practice sessions and offering feedback and guidance as they navigate through different scenarios, may emphasize on the understanding and mastery of concepts rather than completing tasks within a set timeframe.

A learning environment that supports trainees' learning and skill development can be created by prioritizing competency-based progress and effectively leveraging remote simulator instruction.

4.3.2. Learning management system

Competency-based instruction can be greatly facilitated by using a Learning Management System (LMS), particularly in a remote or online learning environment. The task of flight instructors is to create competency frameworks that outline the specific skills or knowledge areas that trainees must master. Utilize the versatility of an LMS to create personalized learning paths for every student based on their current level of comprehension and progress. By doing this, trainees can concentrate on areas that require improvement and move forward at their own pace. The use of the tracking and reporting features of the LMS to monitor trainees' progress

towards mastering competencies and the generated reports that provide insights into individual performance, allows the instructors to intervene as needed to support their training progress and process.

By leveraging the features and capabilities of a Learning Management System, you can create a dynamic and personalized learning experience that supports competency-based instruction and helps trainees develop the skills and knowledge they need to succeed.

4.3.3. AI Instruction – early gains impressive

AI-driven instruction can lead to impressive early gains when incorporated into the flight training process. Analyzing individual strengths, weaknesses, and learning styles allows AI to customize instruction accordingly. Trainers can focus on areas where they need the most support through this personalization, which leads to faster progress and deeper understanding. Content and difficulty levels can be adjusted in real-time based on performance by AI-powered systems. The use of this adaptive approach ensures that trainees are challenged and engaged in a way that maximizes their learning outcomes. Moreover, AI can provide immediate feedback, facilitating the correction of misconceptions and reinforcing learning objectives. The

learning process is accelerated and errors are less likely to be repeated due to this immediate feedback loop. Additionally, AI is capable of analysing a large amount of data on trainees' performance to identify patterns, trends, and areas for improvement. Instructors can make informed decisions about instructional strategies and interventions through this data-driven approach.

The role of instructors can be enhanced by AI through automation of routine tasks and basic explanations, which is probably one of the most important aspects. This frees up valuable time and reduce instructor burden in the training process, allowing instructors to focus on more than one trainee at a time or at a more difficult task.

4.3.4. Mixed reality

The integration of physical and digital worlds through mixed reality (MR) presents exciting opportunities to revolutionize flight training. Immersive learning experiences that take students to virtual environments or simulated scenarios can be achieved through mixed reality. Through experiential learning, this immersive approach enables a deeper understanding. Collaborative learning experiences can be facilitated by mixed reality platforms, where individuals can work together in virtual spaces

regardless of their physical location. Through this, teamwork, communication, situational awareness, problem-solving, and decision-making are encouraged.

By simulating authentic scenarios and challenges, mixed reality technology allows trainees to apply their learning to real-world contexts.

4.3.5. Augmented Reality

Augmented Reality (AR) offers tremendous potential to enhance education by overlaying digital information and virtual objects onto the real world. AR enables us to witness the natural world unfold in front of us, all while being augmented with digital elements. The content and interactions can be adjusted by this technology to meet the individual needs and preferences of each trainee. AR's training engagement and self-directed learning can be enhanced by offering personalized feedback, guidance, and scaffolding. Additionally, it facilitates learning experiences that involve collaboration, allowing trainees to work together to solve specific tasks, complete missions, and explore virtual worlds. AR equips trainees with the necessary skills to succeed in real-life work environments by emphasizing teamwork, communication, and collaboration. Experiential learning can be achieved through the use of Augmented Reality, where trainees

are immersed in simulated scenarios and realistic simulations. Military fighter pilots see an projection of their altitude, speed, and other data on their helmet visor, which means they do not need to waste focus by glancing down to see them [10]. To conclude,

AR offers opportunities for engaging and impactful hands-on learning.

5. NEXT GENERATION TRAINING

The Air Force needs to develop more capable and self-sufficient aviators who can handle a dynamic and fluid environment with more efficiency than ever before.

5.1. Competency based, not time based – progress with student understanding

To foster genuine student understanding and long-term success, it is crucial to prioritize competency over time in education. Competency-based education emphasizes the importance of students understanding and applying the material before moving forward. This approach encourages mastery of concepts, rather than merely completing assignments within a set timeframe. Students are given the chance to deeply immerse themselves in the content until they have a complete understanding of it. Competency-based education caters

to diverse learning paces and methods by providing a tailored experience for each student. Using individualized progress, rather than forcing everyone to progress together, students move forward once they have demonstrated proficiency, regardless of the pace.

In the Air Force, the emphasis is not just on completing tasks swiftly but on doing them accurately. Competency-based training focuses on acquiring practical skills and knowledge that can be applied in real life situations. Students learn to focus on quality rather than speed, better preparing them for future missions. Allowing students to progress at their own pace while recognizing their achievements fosters a sense of accomplishment and intrinsic motivation, ultimately better preparing them for future missions through attention to quality. Engaging instruction can lead to improved learning outcomes.

5.2. On-demand, On-command Availability – learning available any time and place

On-demand, on-command learning has revolutionized education, making it possible for students to access educational materials and resources anytime and anywhere. This method frequently uses technology to deliver custom learning experiences suited for individual students. Adaptive

algorithms provide students with personalized recommendations, feedback, and learning paths according to their unique strengths, weaknesses, and learning styles. This personalized approach boosts engagement and encourages deeper comprehension.

Bearing in mind that the foundation of all flying is built on mental ability, cognitive performance specialists should aid the students in nearly every part of the training. Those specialists should also help students and instructor pilots understand the way they think and how it correlates with how they perform. They help cross the communication barrier between students and instructors by teaching briefing, debriefing and adult learning strategies to the instructors [11].

5.3. Self-directed learning should be encouraged - learners learn best when they are in charge of their own journey

Empowering and recognizing self-directed learners is crucial for nurturing students' potential and encouraging a proactive approach to learning. This self- directed learning fosters autonomy and independence, allowing students to take ownership of their education. More than that, students can pursue their interests, acquire new skills, and stay up-to-date with the latest developments in

their field, even after completing traditional training. This ongoing learning contributes to professional growth, career advancement, and personal fulfillment.

5.4. Self-directed learners should rise to the top – system should identify and reward "aggressive learners"

Encouraging self-directed learners to excel is essential for cultivating a culture of initiative and lifelong learning. The personalized education system enables self-directed learners to flourish by catering to their unique requirements. In addition, encouraging self-directed learners to assume leadership roles can further incentivize their proactive approach to training. The system acknowledges their abilities and value by assigning them responsibilities.

By implementing these strategies, "aggressive learners" are identified and rewarded, enabling them to rise to the top and contribute significantly to their growth and the system's success.

5.5. Training data should be a decision aid in career development and operations

Adopting this approach holds various advantages. Trends and patterns in training can be identified through data analysis. Instructors can make informed decisions regarding their students' training needs based on this information. Furthermore, instructors can determine which skills are most valuable for students by analyzing the skills gap in various stages and focusing their training accordingly. Moreover, using completion rates, quiz scores, and time spent on training modules as metrics, the Air Force can evaluate their training programs' effectiveness, target improvement areas, and enhance student, instructor, and systemic performance. Additionally, resource allocation and planning decisions can be influenced by training data. Air Force HQ can allocate training budgets more effectively, prioritize initiatives, and tailor programs based on training needs analysis and performance trends. By continuously collecting and analyzing training data, the system can identify areas for improvement and refine their training strategies over time. This iterative approach ensures that training programs remain relevant and effective in meeting the evolving needs of the modern battlefield and warfare.

Overall, leveraging training data as a decision aid in career development and operations can lead to more informed decision-making, personalized training, improved skill development, enhanced performance evaluation, more effective resource

allocation, and continuous improvement in the training programs.

6. CONCLUSION

It's undoubtedly true that technology has unexpected effects on how we live, work, and educate our children. Twenty years ago, the Internet was the stuff of science fiction, but education and government leaders had the foresight to develop a solid foundation on which the future of technology planning would rest [12].

"The old way was to keep going up in the air and practice a maneuver over and over until you figured it out. It wasn't very efficient. Now, if they can recite knowledge while they are doing a strenuous task, they probably know that information well, and they'll be able to access it in the jet." [13]

Through the creative use of technology, the next generation of training should aim to transform student pilots into professional athletes. This approach has the potential to offer more personalized and flexible professional development, while also offering sustained and substantial professional development that facilitates student-centric, self-directed, On-demand, On-command Availability, and immersive learning.

Digital technologies will make their way soon because of improved performance and cost reduction, which should lead to widespread acceptance and adoption.

Furthermore, it is crucial that these technologies are present in their training from day one or, if possible, prior to formal military training, in military high schools.

We spend millions of dollars per student pilot, so why not maximize this investment and ensure they have the proper training to serve in a future battle space that will be highly contested and more lethal than what we have experienced.

The stage is now set to create a plan that will help us chart the course for education technology for the next twenty years [14].

ENDNOTES

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