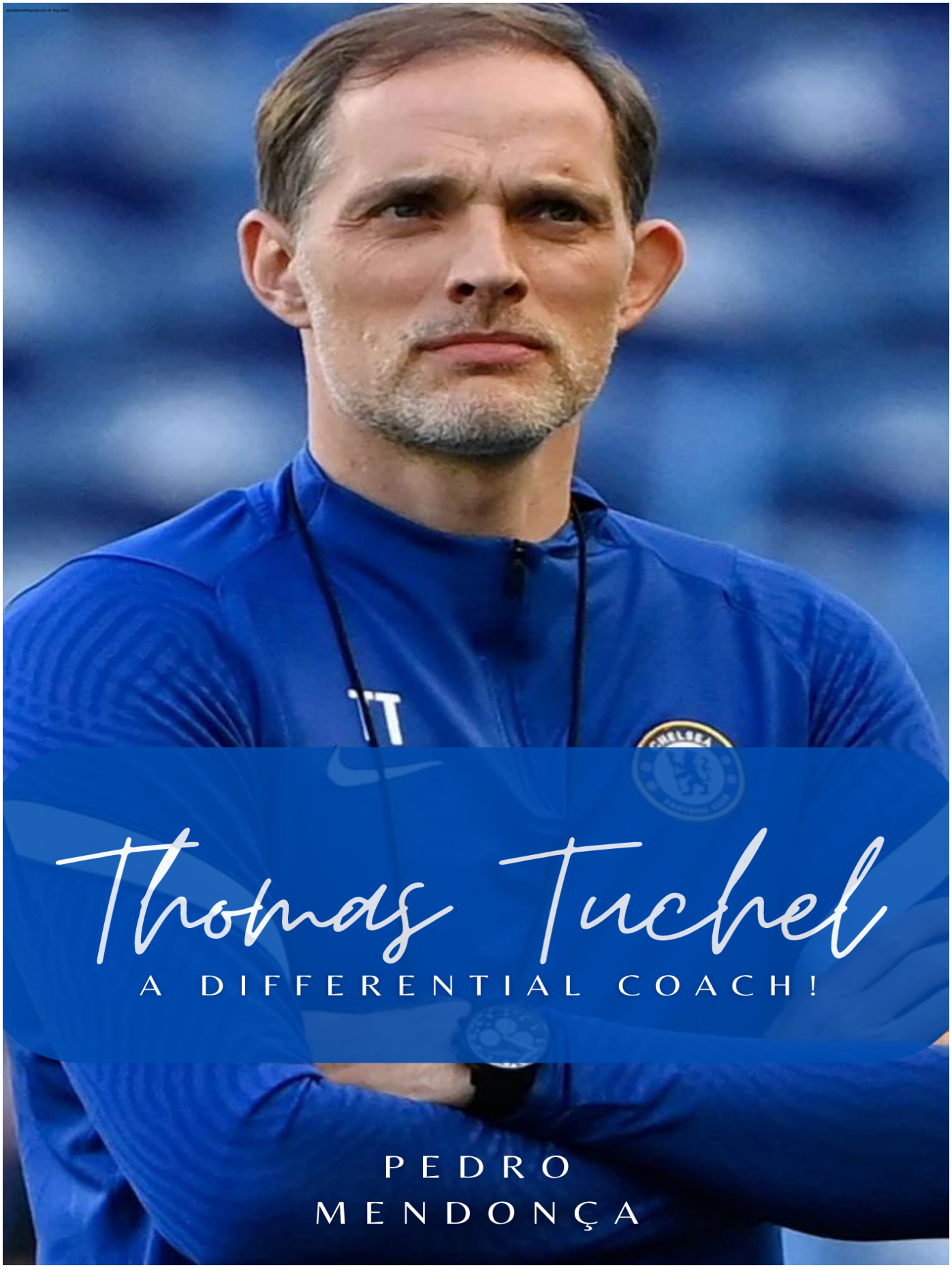
Thomas Tuchel
A DIFFERENTIAL COACH!
PEDRO
MENDONÇA

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“PERHAPS FORGETTING SUCCESS - THE SURPRISING AND REMARKABLE SUCCESS - IS EVEN MORE IMPORTANT THAN FORGETTING FAILURES!”

Thomas Tuchel

INTRODUCTION

Who is Thomas Tuchel?

He likes the band *Simply Red*.

He knows in detail how to inspire others, not just talking football with his footballers. He likes to know their private lives and aspirations to understand the players' personalities and understand what makes them the men they are.

He is excellent at understanding the strengths and weaknesses of teams. For example, he pushes opponents into the right areas to recover the ball, leaving specific spots open and setting traps in them.

When facing better teams, he has no problem playing counter-attacking football.

Thomas Tuchel's goal is to make his footballers improve day by day. He wants them to reach their full potential to increase the chances of achieving satisfactory results.

His idea is to make training sessions more complicated than matches. Some examples are the use of slippery surfaces to develop the footballers' balance and ball control. Or the players having to control the ball with their thighs first (even when the ball is passed low to the ground).

Constantly trying to gain an advantage over the opponents, he instigates his footballers to develop code words when they attack, so that everyone knows where to attack the depth and the target to look for. This way they will know which way the teammate will run, whether the ball should be played through the air or on the ground, and whether closer or further away. This makes his teams' play quicker and deadlier. Often, the ball carrier doesn't even need to look at the unmarking teammate.

100% focused on winning, he is a born competitor, focused, energetic and patient. He enjoys being in the best competitions, facing the greatest football coaches in the world.

He likes to set the bar extremely high and demands the maximum!

He knows that football clubs play for trophies and reliable results. He wants to win silverware!

His goal is to always achieve the best he can (he demands a lot from himself and his footballers).

REECE JAMES ON THOMAS TUCHEL

"The coach wants me to believe in myself more and more and that I can become one of the world's best. He gives me a lot of advice about game situations, how and where I can do better. Sometimes he shows me videos, sometimes we just talk face to face. He is a friendly person, but quite serious when he needs to be. When we're not playing well, he's not afraid to tell us. He makes us practice with smaller balls or has us play only on our tiptoes. With this, he doesn't let us fall into a routine and makes us think all the time."

CESAR AZPILICUETA ON THOMAS TUCHEL

"His arrival was important for me. From the first day, we established an extraordinarily strong connection. He explained what role he wanted me to play as team captain from day one and from the first team talk. He clearly showed what he wanted, where we could cause damage to opponents and where we could improve. He shares the responsibilities with the footballers. We always had highly honest conversations."

MATEO KOVACIC ON THOMAS TUCHEL

"We became more solid and confident at the back. We have conceded virtually no goals at all since Thomas Tuchel arrived at Chelsea FC. We are playing with confidence."

ANDREAS CHRISTENSEN ON THOMAS TUCHEL

"The days before matches are a bit more difficult than usual."

JORGINHO ON THOMAS TUCHEL

"Training with different sized balls is fun. It's different and, besides being fun, it helps to improve the skill. We enjoy training like this. He is friendly with everyone (footballers, staff and club employees), everywhere (on the training ground, in the training centre and at matches)."

NEVEN SUBOTIC ON THOMAS TUCHEL

"At first, we wondered about Thomas Tuchel's training methods and what they had to do with football, but we quickly realised that they worked."

KONSTANTIN FRING (COACHED BY THOMAS TUCHEL AU U19 MAINZ 05)

"He had an interest in knowing every footballer. He was particularly good at 'dissecting' each of us: he understood our weaknesses and our strengths as footballers, but also as human beings. He could read the opponents' game, always knowing where they were vulnerable. He would give us specific instructions and the means to put them into practice. For example, he would make us play on a banana-shaped pitch or one without vertices. There was always a plan behind every training ground, because it forced us to do specific things that would be useful in matches. He is also a great motivator. During the pre-season, we did a bike ride through the hills and then hiked the last few metres to the top of the mountain. Tuchel buried a metal Mainz 05 pin and told us that, if we reached the U19 German League final, he would cycle back up the mountain to dig it up. Ten months later, just minutes before the U19 German League final, he showed us a video of him cycling up the mountain and digging up the pin. After the video ended, he held the pin in his hand and slammed it down on the table, shouting: get in there and play! We got goosebumps and felt a huge urge to win (which we did - 2-1 win over Borussia Dortmund). At that moment, we could do anything for Thomas Tuchel."

THOMAS TUCHEL'S LUCKY SHOES

The Paris SG president offered Thomas Tuchel some special shoes and he promised him he would use them in the Champions League final. However, Thomas Tuchel forgot them at home and did not wear them in the lost final against FC Bayern Munich. The German coach thought he should have kept his promise. The following year, when he reached the Champions League final again, he told his wife to send him those shoes so he could wear them in the final against Manchester City. On the day of the final, Thomas Tuchel explained the situation to the players and told them that what he had learned from the previous final was the need to keep one's word. They were not to worry, because on that day he would wear his lucky shoes. And the rest is history. He kept those lucky shoes, at Pulisic's suggestion, so he could wear them in the next finals.

1. THOMAS TUCHEL'S PHILOSOPHY

The desire to win must be greater than the fear of losing!

Thomas Tuchel likes his teams to attack (he invests all available time thinking about how he can score goals and how to recover the ball as high and fast as possible).

For him, the key word is *ATTACK*:

i) Attack the opposition goal;

ii) Attack the spaces and attack the box;

iii) Attack the opponents when his team doesn't have the ball.

To reinforce this attacking mentality, Thomas Tuchel says he spends only 10% of his daily work working on defensive movements and patterns. He believes that the football game has as its cornerstones attacking, having the ball and recovering it immediately after losing it.

He also believes that the team must keep a structure, even during attacks, to be ready to recover the ball again after losing it.

Regarding tactical systems, Thomas Tuchel has no problem changing them if it is beneficial for the team. But he is careful not to change them too much. Constantly changing tactical systems, for example from one match to another, can convey the impression to the footballers that the coach always has a solution to win and that they can expect it. The most important is not the tactical system, the most important is how the footballers interpret it, how they respect the game principles: how to attack and defend in that game system.

Teams can be strong under any system. For example, at Chelsea FC, he started using a 1-5-4-1 (defending) and 1-3-4-3 (attacking) due to the footballers' attributes and the opponents he faced.

Playing with three centre backs allowed him to defend with a five-man line, applying quick pressure and achieving numerical superiority when facing the two opposing centre forwards.

Footballers must adapt during the match. For example, when facing a team with three forwards pressing the three centre backs, the system should be changed to a four-man defensive line. This relieves the pressure exerted by the opponent.

Footballers must realise that the changes between a line of three or a line of four are not that big. Often, a small 10-meter shift, going up the pitch or going further to the side-line, is enough. From there, footballers go back to doing what they are used to: playing the ball forward, making diagonal passes, etc. That's why footballers are always the most essential element.

He requires his teams to show intensity and "hunger". Footballers must show devotion, always give their best, playing every match at the highest level.

The importance of "Counter-Pressing": In matches where it is difficult to create scoring chances, we must use "Counter-Pressing" to force opponent mistakes and win a second ball to have an easy chance to score after recovering it. For that, we need to be fully committed and attentive.

2. MATCH PREPARATION

After every match, Thomas Tuchel conducts a video analysis to find strong and weak points.

During the pre-match, Thomas Tuchel and his staff check the level of the two teams. When they feel inferior to the opponent (team spirit, tactical ability, mental ability, physical ability or individual quality), the approach to get a positive result is this:

i) *observe the opponents;*

ii) *observe the opponents;*

iii) *observe the opponents*.

With this detailed observation, they will clearly define what they do and how they play.

The next step is to *mirror* the opponents. They try to anticipate the geometric shape of the opposition. They do this so that each footballer fully understands the defensive actions when the other team has the ball, because in every gap of the pitch there is always an opponent on whom they can engage. Footballers are aided to act instinctively, without having to think too much or speculate, arriving in time for duels..

This pre-match pattern helps the team nurture a proactive attitude, entering more easily into a state of flow to avoid speculation and uncertainty about who should attack the ball in certain areas, for example.

Thomas Tuchel thoroughly prepares each match to succeed. Some of the questions asked during the pre-match by him and his staff:

i) Who do we need to play these roles?

ii) Which tactical system (or adaptations to the tactic used) is more appropriate?

iii) What are we going to do?

iv) What and where is the advantage?

v) Which footballers can make the difference against direct opponents?

2.1. PREPARATION FOR THE CHAMPIONS LEAGUE FINAL AGAINST PEP GUARDIOLA'S MANCHESTER CITY

Thomas Tuchel used to his advantage the fact that many took Pep Guardiola's Manchester City's victory for granted. Throughout the preparation week before the final, he used this to motivate his footballers. He knew the underdog tag was positive for his team.

After an exceptionally long season, the footballers were highly fatigued. So, Thomas Tuchel, after the end of the Premier League on Sunday, did a light recovery session in the morning and gave the footballers the afternoon off on Monday and Tuesday. This allowed the footballers to recover physically and mentally for the big final against Manchester City.

On Wednesday and Thursday, the intensity of the training sessions was extremely high. On Friday, with the team already in Portugal, Thomas Tuchel tried to keep the atmosphere as relaxed and fun as possible. We can notice that, during the last training session before the match, at Estádio do Dragão, Porto, many Chelsea FC footballers were smiling, making the most of that unique occasion, without feeling the burden of the moment.

2.2. PRESS CONFERENCE ON THE EVE OF THE FINAL

In this press conference, Thomas Tuchel revealed that the preparation for the final followed the usual routine, with tactical talks and tactical sessions, dividing the offensive and defensive workload. The approach to Manchester City was to show this team and their coach (Pep Guardiola) as football benchmarks. But always saying that it was possible for Chelsea FC to reach that level, playing with courage, bravery, suffering, strength and quality.

He also said that he prepared the team for several possibilities. One can never anticipate what happens during a match. In his opinion, the coach should not give the idea that he knows everything, because that is not the case. He worked out the game principles he wanted for his team and to deal with Manchester City's. His idea was to aggressively attack and defend.

He showed he was prepared for a penalty shootout. "We always practice penalties before a match that can be decided that way." He admitted it is

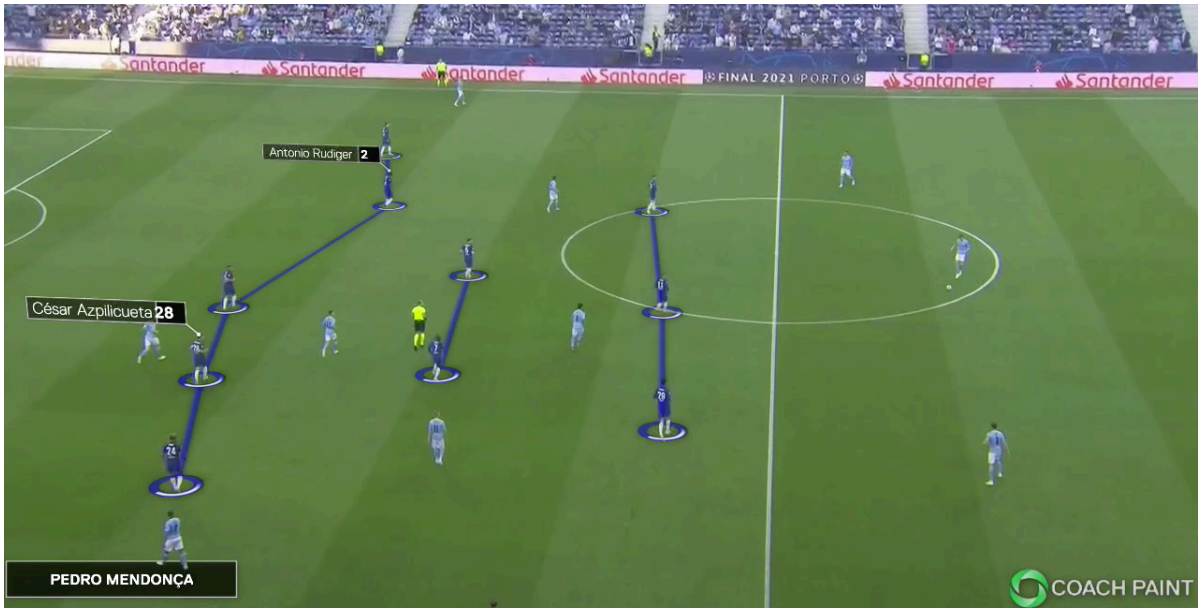
impossible to replicate the mental pressure, the fatigue, the decisive moment and how the footballers will feel. But, even so, he believes that managing some patterns, pace and habits during penalties is feasible (and that's what they did). He identified the footballers who were expected to take the penalties, but that choice would depend on who was on the pitch at the time.

2.3. TRAINING SESSION ON THE EVE OF THE FINAL

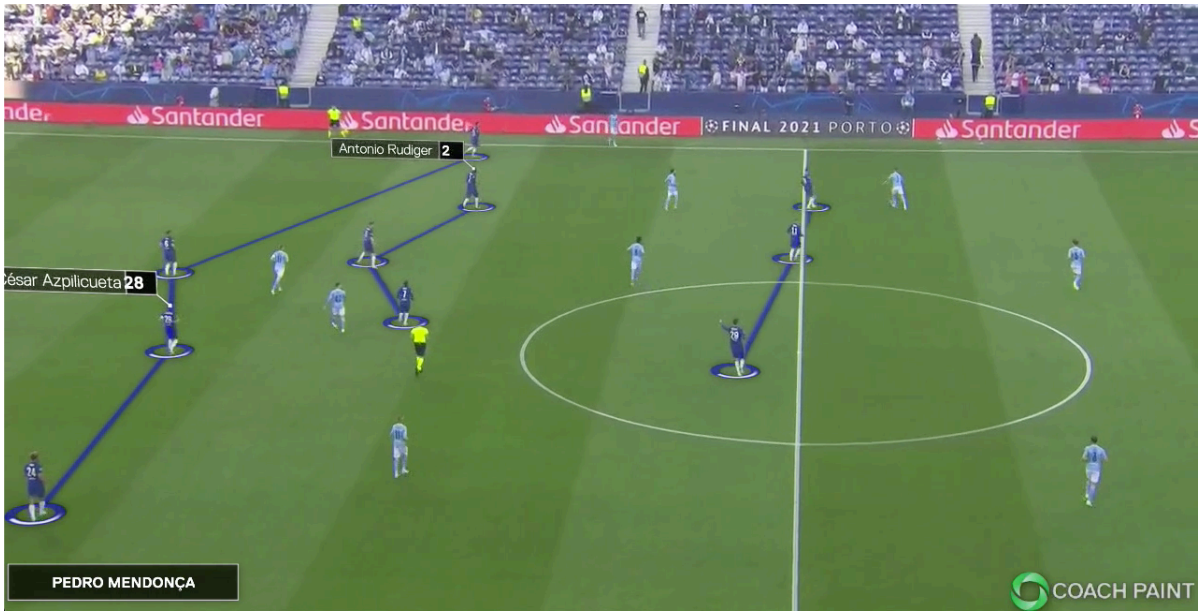
2.4. PRESS CONFERENCE AFTER THE CHAMPIONS LEAGUE VICTORY

In this conference, Thomas Tuchel revealed details of the game plan that were crucial to the victory. Playing preferably in a 1-5-2-3 system defensively, they would be outnumbered in the midfield as Manchester City played in 1-4-3-3. Thomas Tuchel's solution was to put Azpilicueta or Rüdiger in the midfield (depending on which side the ball was on) to ensure numerical equality and avoid side switches through diagonals in the midfield.

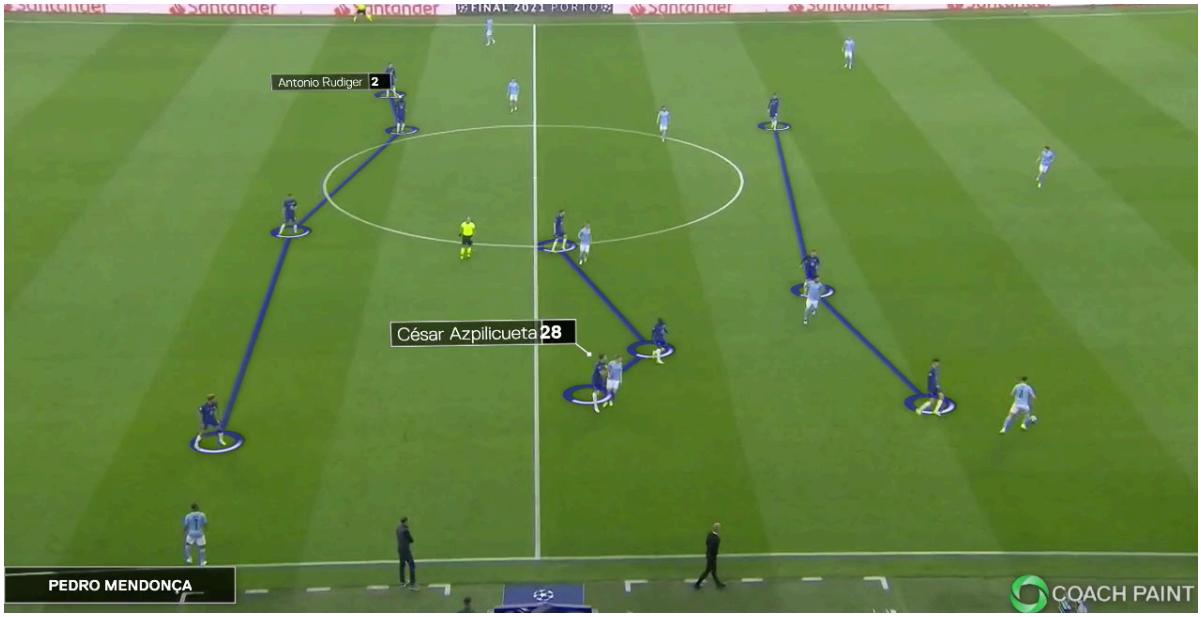
Game System 1-5-2-3:



Antonio Rüdiger's move up into the midfield (ball on Manchester City's right side):



Cesar Azpilicueta's move up into midfield (ball on Manchester City's left side):



He said it was time to celebrate the huge achievement but, after that, everyone was to return to the club with a hunger to win more trophies and a desire to achieve the next success!

3. CHANGING FOOTBALLERS' BEHAVIOURAL HABITS

Changing the habits of teams and footballers is not easy. For example, many teams try to play down the wings as quickly as possible and attack from there. That happened with some of the teams coached by Thomas Tuchel. For the German coach, those were not the offensive behaviours intended (it is always easier for a football team to recover the ball on the wings than on the middle of the pitch). This way of playing through the wings is very ingrained in footballers because it is comfortable and safe. To break these habits and promote more diagonal passes in the middle of the pitch and from back to front, Thomas Tuchel "cut" the vertices of his training grounds, forming a hexagon. Why? In his game principles, it is important to make diagonal passes and attack from the middle of the pitch. Therefore, footballers must accomplish this task on the pitch, preserving their maximum creativity, but always within the limits of the pitch format. Although there are no specific guidelines for the footballers, the pitch format makes the footballers follow the desired principles without the need for the coach to constantly interrupt the training session.

Therefore, the coach's role is to observe how the footballers perform in this space, whilst assisting them to best adapt to what is intended. The coach's role is to provide support to the footballers and not to be the constantly angry critic.

Thomas Tuchel also used tennis balls in his training sessions at Mainz 05 and Borussia Dortmund in 1v1 and 2v2 situations. He wanted the footballers to not grab the opponents' jerseys, but instead use their arms and elbows to push them (the referees call less fouls in these situations compared to grabbing the opponent). This idea was "stolen" from another team and was the solution for his footballers to stop grabbing their opponents so much.

These behavioural patterns in training are sustained, expanded and updated using the latest knowledge gained from brain research. Their teams perform an infinite number of repetitions, but without standardization. There are no standardized pass sequences, like for example from no. 4 to no. 2, from no. 2 to no. 10 and from no. 10 to no. 7, with a cross for goal in the box. The training is also global: everything is rehearsed. For example, they don't spend three months training one thing and then another three months training another. Everything is always practiced, from the first to the last season session.

The training is done in different spaces depending on the layout (hexagon, octagon, square, circle, rectangle), dimensions (18m wide by 75m long, 70m wide by 30m long). In training, Thomas Tuchel does not usually use the 11v11 within the pitch's regulatory proportions. In his opinion, copycatting the game in training sessions is impossible. What is possible is to try to generate the flow state in the footballers and keep them in action by putting them in countless situations with a high number of repetitions. This way, they can produce solutions by themselves, and it is easier to adapt to what happens in the official game.

4. DIFFERENTIAL LEARNING / DIFFERENTIAL TRAINING

Thomas Tuchel likes to use smaller balls in training sessions and tries to do many different things to keep the footballers excited. He strives to make sure they always train with a smile. Daniel Alves (then a Paris SG player) is proof of that. He said that, with Thomas Tuchel, he regained the pleasure of working and doing things with a smile and a lot of energy.

Regarding his training methods, Thomas Tuchel encourages fun with new and constant challenges for his players, making them curious to try different things. For the German coach, adaptation is the main cornerstone. Apart from these different situations without much significance, Thomas Tuchel also trains some standard situations which can be applied in the upcoming fixture. In general, however, he proposes tasks to the players so that they just carry them out and find solutions autonomously. To do this, he proposes activities in different spaces, with bigger or smaller balls, etc.

When playing on the most demanding level, players need plenty of tools to meet the requirements and "answer" all the "questions" asked by the opponents (the coach can't predict the game).

Many of these concepts emerge directly from ***Wolfgang Schöllhorn's Differential Learning***.

4.1. DEFINITION

The philosophy of ***Differential Learning*** is: "never practice the right thing so we can play well" (reinterpretation of Bernstein's mantra "repetition without repetition") - Wolfgang Schöllhorn.

The term "differential" was chosen to underline the slight differences between two movements in a row (even when it is the same person performing them). And also to reinforce the need of having differences to acquire new knowledge.

Differential Learning is based on the idea that learning requires differences facilitated by the addition of stochastic perturbations during the learning process. Depending on the individual situation, this model, in its most extreme version, is associated with the absence of repetition and increased feedback, allowing for a

real process of self-organisation. The subject is not given any explicit guidance on the solution by an external agent. Errors are not even mentioned.

Differential Learning recommends high variability.

It is especially important to execute "wrong" variants of a task without ever repeating them

In the limit, the intended movement may never be executed during the acquisition process.

This originates in the "*Practice Variability Theory*", which suggests the stabilisation of an automated movement by exclusively repeating the invariable elements of a "movement to be learned" (e.g. a shot), together with several variable patterns (e.g. shooting with the inside or outside of the foot, shooting with the opposite foot, shooting with the supporting foot in a different position in relation to the ball, shooting with the arms positioned in different ways, etc.), according to *Schmidt's Scheme Theory (1975)*.

The objective in ***Differential Learning*** is to induce a self-organised learning process, during which the subjects improve their performance according to their individual skills and preferences, always depending on the context. For this, the players practice many exercises. These make the players aware of the range of movement patterns potentially available. An important idea is to increase the differences between followed movements to generate additional information for the system.

The fundamental idea - i.e., movement variability is necessary for the operation of an adaptive system - goes back to the dynamical systems perspective. Here, fluctuations are considered necessary for functional adaptations to volatile environmental contexts and for preventing the loss of system complexity as constraints change. Deviations from the intended motion are not considered errors, but fluctuations and intermittencies in the system's organization.

In **Differential Learning**, an ideal/resonant noise is sought, as well as the implementation of stochastic perturbations ideas that is situational and individual.

Differential Learning is characterised, for the sake of learning, by taking advantage of the fluctuations (differences) that occur, without movement repetitions and without corrections during the skill acquisition process, assuming that:

I. Learners should not be distracted from task-space exploration by corrections:

- The key constraints of the tasks are not mentioned.
- Due to the continuous differences between movements, no emphasised feedback is recommended.
- Tasks should not be detailed with training instructions. The movements that emerge are due to self-organisation and adaptation of the subject to the existing conditions.

II. Learning is aided by wide fluctuations between trials:

- Learning is induced by the differences between two consecutive trials rather than by attempting identical movements. Further intensification of fluctuations is expected to increase performance.
- Through a permanent process of creating differences between two consecutive movement executions, the "*noise*", always present in the movement, is amplified so that the learner is constantly challenged to adapt his motor behaviour by creating new movement configurations. For example, different body constraints (both hands on the head, one hand on the shoulder, both hands on the hip, etc.), different types of balls (rugby ball, tennis ball, reflex ball, etc.) and different materials (wearing sunglasses, playing barefoot, etc.) may be used during a scoring task to increase the adaptive mechanisms that sustain performance with each shot.
- Thus, individuals are stimulated to find ideal individual performance patterns to succeed in certain complex motor skills (these are particularly important in football and involve many degrees of freedom related to the high number of musculoskeletal components in motor performance. For the performance to be successful, a high degree of coordination is required). Self-organisation is fundamental to associate the degrees of freedom of motor control components with synergies (simultaneous act or effort of several organs or muscles). To this end, training sessions should be *noisy*, including many differences between exercises.
- To enhance learning, increasing the ratio of deviation in relation to the previous exercise is fundamental.

- The exploration of the increased fluctuations in the movement patterns of the learners requires adaptive mechanisms of the perception-action system from them.
- The participant is challenged to do many varied exercises, without repetition, which mimic various conditions where they will have to reproduce the movements.
- The variations in training include changes in any combination of these characteristics: joint manipulation, movement geometry, movement speed, variation in training materials and in environmental conditions. These imposed fluctuations create a need for adaptation and force players to create movement responses that are unusual but fully appropriate to the context.
- The most relevant ingredient of training is variation between exercises.

Differential Learning has two main properties:

I. It is a self-organizing process:

- The movement pattern is not specified by the training instructions. That is, instructions do not force players to produce a particular movement pattern.
- The variation between exercises cannot indicate a particular movement pattern (generic characteristic of self-organized systems).

II. It is a process that emerges in a bifurcation:

- ***Differential Learning*** emerges in a noise-induced bifurcation. That is, the control parameter corresponds to the variation of the training exercises (therefore, bifurcations are a central issue in the dynamic systems approach to human movement).

The goal of ***Differential Learning*** is to establish or improve the player's skill at the moment when it is necessary to find successful behavioural patterns by permanently changing the internal and environmental conditions. Hence, the relationships between the components of motor control do not converge on a fixed set of coupling functions. The relationships are constantly changing. Differential Learning is not about cultivating a particular cooperation, but rather a new learning behaviour.

Accordingly, ***Differential Learning*** is accessible to everyone at any time. Noisy training through differences is just a means to activate this learning process. The activation energy of the process is guaranteed by noisy training sessions (activation energy that only must be provided once). Activation can be achieved through various means.

Differential Learning emphasizes that players use random variability to find information about future performances and not only to differentiate between immediate performances of a skill. This performance information can be derived from all movements of an idealized motor solution, which are usually considered by coaches as movement errors or irrelevant actions.

4.2. STOCHASTIC PERTURBATIONS

A stochastic perturbation is any random sequence of variations in movement elements, where the perturbations can have internal or external origin.

The term stochastic is usually used to describe systems under the influence of a random variable (undetermined or unpredictable events). The term is a measure for uncertainty and applies to concepts of chance, probability and entropy. In this way, the term random characterises a selection process where each variant has the same probability of being chosen.

Learning is characterised by an improvement of internal adaptation processes and is achieved by adding stochastic perturbations to a given "ideal motion".

Differential Learning indicates that motor learning may benefit from the addition of stochastic perturbations, as variable or random movement components, to a desired standard movement. In this context, stochastic perturbations may be fluctuations that naturally occur during multiple repetitions of a movement. The term stochastic is used to underline fluctuations in repetitions of motion that do not seem to follow any deterministic structure or rule, although they can also be chaotic and non-noisy.

Systems that have an energy exchange with the environment are characterised by showing constant fluctuations. In these systems, the transition from one stable state to another is usually accompanied by an increase in fluctuations, which cause periods of instability. During this transition phase, these systems can be interpreted as exploring several modes to find new and more effective states.

The fluctuations are increased by adding stochastic perturbations.

The increased fluctuations will be an active tool to lead the system into a zone of instability, where less energy will be required to reach a new state.

Therefore, the **Differential Learning** approach takes advantage of the existing fluctuations in a complex system by increasing them through "non-repetition" and "constantly changing tasks and movements", which increase stochastic perturbations.

With more fluctuations, the result of adding stochastic perturbations to a "movement to be learned", the **Differential Learning** approach initiates a self-organised learning process, where the subject will find an individually optimised solution to the movement problem. The "movement to be learned" must not be repeated in its optimal form.

Fluctuations in the subject's subsystems are exploited during learning, as they have the potential to destabilise the entire system. This destabilisation process can cause an instability, which requires less energy to achieve a new and stable state of organisation for the subject. Through the amplification of these observed fluctuations, the system is also confronted with the potential limits of performance solutions. Consequently, a process of self-organisation is initiated and exploited, forcing the system to create a new coordination strategy. This typically results in more effective or stable movement patterns. These heightened fluctuations may increase fluctuations in other anatomical areas of the body, creating a highly non-linear adaptation process.

4.3. NOISE

During **Differential Learning**, the fluctuation dynamics of the subjects' performance are in line with the external force of the stochastic perturbations, caused by the executed movement. In this context, finding the most effective approach for motor learning, operating according to a maximum learning rate, is equivalent to finding the optimal noise for each subject's task in each situation.

Noise is a term that usually describes unwanted disturbances or fluctuations. In biology, it usually refers to the variability of measured data when identical experiments are repeated, or when biological signals cannot be measured without background fluctuations, which distort the desired measurements. There

are circumstances where the presence of noise is unavoidable and unpredictable fluctuations can be used or deliberately introduced to extract a benefit.

A similar, active and constructive role of noise exists in robotics research and Artificial Neural Networks (ANN). When a robot is confronted (trained) with noisy stimuli within a permanently changing environment during the training or learning phase, we can observe a much better guidance according to different conditions in the application phase, compared to a robot trained in a constant environment.

Training ANNs with noisy data achieves better recognition rates also in the application phase.

From a scientific point of view, the optimal (individual and situational) noise for practicing a sequence includes randomness and graded sequences. An infinite spectrum of sequences is described to achieve optimal noise.

Optimal noise: an environment where experiences have slight variation can "destroy" the individual's self-organising capacity. However, we must remember that the learning rate drops to zero if the noise level is too large.

Fluctuations are a specific form of noise, and increased fluctuations are applied to movement learning in general.

Finding the optimal noise is key, as a drop in learning rate can happen when there is too much noise in the system. This may explain why children (beginners) show better learning rates with little contextual interference, while adults are more successful with higher levels of contextual interference.

It is likely that children's (beginners') movement repetitions have an elevated level of variability or noise, which may cause a negative effect if additional noise is applied to the learning experience. On the other hand, more advanced individuals have reduced levels of variability within their movement repetitions, leading to insufficient learning progress and thus requiring additional noise.

The simple initial amplification of noise is differentiated in the mutual optimal tuning of two noisy signals: one coming from the chosen exercises, which corresponds to objective information; the other caused by the subject's movements as subjective information. The fine tuning can potentially be described by the Stochastic Resonance model.

4.4. STOCHASTIC RESONANCE

The concept of **Differential Learning** is associated with the phenomenon of Stochastic Resonance, as this can benefit training when two noisy signals interact in resonance. One noisy signal comes from exercises in continuous change and the other noisy signal is formed by the noise, dynamic condition of each subject (for example, during repetitions of movements). By proposing a footballer (for example) a greater number of activities in training, the probability that some training exercises will resonate with his needs increase.

Stochastic Resonance is a phenomenon described by Benzi, R. (1981). It is characterised by an increase in the sensitivity of a sensor after the introduction of a suitable level of (random) noise. This noise improves the sensor's ability to identify signals previously unnoticed and, therefore, not used by the system. This phenomenon is observed when the levels of unpredictable fluctuations (random noise) are increased, causing an increase in the quality of detection or transmission of a signal. Stochastic Resonance in this context is an applied term that describes any phenomenon where the presence of noise in a nonlinear system is better for the quality of the output signal than its absence. Whenever this occurs, this equation must always be true:

Performance (noise + nonlinearity) > Performance (nonlinearity)

The addition of randomly fluctuating motion components to an "objective skill" can give rise to different emerging motion solutions, even after thousands of repetitions, due to dynamic performance conditions.

Because of randomness (addition of new elements to movement repetitions), resonance effects may be vital for increasing subjects' skill in adapting to these new elements, entering a process of performance differentiation through individualised exploration of movement solutions.

Resonance effects are usually characterised by an increase in the amplitude of the oscillation of a signal exposed to an external force

4.5. CHARACTERISTICS OF DIFFERENTIAL LEARNING

i) Adaptation to constant disruptions:

- Each player movement technique must be prepared when faced with typical disruptions during practice and training programmes.

- If one considers the number of disruptions that can occur caused by a sudden movement of the ball, pressing actions of opponents, pitch, weather conditions or the players' movement, the impossibility of there being two precisely identical situations in skill execution is obvious.

- Since players never have to perform identical movements in a match, having to adapt to constant disturbances in a competitive and dynamic context, the use of training practices that emphasize endless repetitions of the same motor patterns should be seriously questioned.

- In non-linear dynamics, the idea that movements can never be repeated identically also requires us to give up the dichotomous perspective, according to which there are "wrong" and "correct" movement patterns. We should consider both as levels of fluctuation from the pattern of stability.

- To consider errors as deviations from an ideal pattern indicates that they can be considered interchangeable with fluctuations and intermittencies around a stable movement pattern.

- Human movement systems are more open biological systems and cannot produce a single functional solution of movement, but several.

ii) Random Variability:

- Variability as a functional form of noise.

- Based on a dynamical systems perspective, fluctuations are necessary for functional adaptation and to change environmental contexts, avoiding a lower complexity of systems as obstacles change.

- The addition of random variability covers a much wider area in the high-dimensional task solving space.

- Due to the constant presence of noise, a repetitive approach in training will cause slow growth and finely intertwined network neurons in a small area of workable solutions.

- On the contrary, all hands-on learning approaches, which recommend several different exercise tasks during acquisition, can create a larger representation area.

- Internal changes depend on emotions, listening to music, fatigue, instructions, environmental changes, learning and development or ageing. Most of it occurs chaotically and spontaneously.

- Retention and transfer can be considered two elements of the same phenomenon.

- So, learning progression (as system changes) during transfer and retention is a function of time (time scale), like the original movement that was performed during the acquisition phase.

- In the movie "King Richard", where Will Smith won the Oscar for best actor for playing the role of Venus and Serena Williams' father, there is a remarkably interesting scene, which validates the importance of variability in training. The coach of the young tennis players complains to their father, accusing him of taking them to train with other coaches. Film dialogue: Coach: "You get the girls training with other coaches behind my back?" Father: "I am trying to take advantage of their knowledge. They won't be great if they do the same training as any other player in the United States of America".

- Differences between adults (experts) and children (beginners): as a rule, beginners and children have high variability or lower stability in movement, while adults and experts have lower variability or higher stability. While beginners and/or children cause a large number of stochastic disruptions, even when repeating the same movements; adults and/or experts show a higher degree of consistency in movement repetition. Therefore, beginners and children with little repetitive experience should be taught with reduced stochastic perturbations (but still with high variability, as is recommended). Meanwhile, adults or experts with high repetitive experience should have a larger number of stochastic disruptions. In short, we can say that beginners/ children should be faced with less contextual interference, while adults/experts should learn with more contextual interference.

iii) Individuality:

- Differential Learning relies on the acceptance that each movement attempt should be considered individual and unrepeatable.
- Coordination and control processes take place as each athlete strives to meet unique organic structures and task constraints during goal-oriented movements.
- In learning football skills, functional coordination solutions emerge when individual players adapt movement patterns to meet unique organisms, task and environmental constraints.
- The relationship between outcomes and movement patterns establishes whether individual coordination solutions are functional or not.
- A coordination solution that satisfies player intentions (e.g., a football pass executed with the required speed and accuracy) and structural constraints (i.e., not causing damage to the perceptual-motor apparatus) can be defined as functional.

iv) Specificity:

- When the variation of movement sequences includes movements of different modalities (free movements), we can consider that stochastic disruptions have further increased. But the learning progress in relation to the "movement that has to be learned" will be smaller. This proves the need for specificity.

4.6. BENEFITS

Many studies point to higher learning rates in varied practices (such as the **Differential Learning** approach) compared to repetitive practices (in motor tasks).

Differential Learning is more beneficial because it disrupts the learner towards more functional movement patterns during practice. Several studies have shown that, in most situations, interventions that added stochastic disruptions during learning led to improved skill acquisition and better learning rates in participants. This led to performance improvements in the retention phase of learning.

Through numerous scientific studies, it has been possible to ascertain that **Differential Learning** is superior to traditional repetitive learning methods in relation to complex motor skills.

As a result of the sensitivity to initial conditions of chaotic systems, we shouldn't be surprised if, in training sessions where chaotic **Differential Learning** is used, the performance of some players improves drastically, while the performance of others doesn't improve at all.

We must keep in mind that an increase in the learning rate is expected up to an optimal noise level. But, in addition, a further increase in fluctuations is detrimental to learning.

Using **Differential Learning** with a one-day break seems to be more effective than doing it without breaks.

With the use of **Differential Learning**, we increase the sensory integration in various aspects (motor, visual, tactile, proprioceptive, vestibular, etc.), enhancing the development of multisensory movement representation, which causes a higher learning rate. As an additional consequence, this multisensory movement representation may cause an increased stability of the movement representation.

Error processing in **Differential Learning** activates working memory processes - "resource allocation" is one of the cognitive processes located in the working memory model.

Studies showed that the result of prior trials had a substantial influence on the number of resources allocated to program the following movement, whenever motor tasks were repeated multiple times.

It has been proven that "resource allocation" is an important part of processing movement errors. A basic assumption is to believe that errors in motor performance force individuals to reinvest cognitive resources into movement control (greater performance errors are achieved through **Differential Learning**).

The results of prior attempts have a major influence on the amount of "allocated resources" to program the next movement when motor tasks are repeated multiple times. The researchers concluded that there are more "allocated resources" when previous movement attempts contain errors.

Electroencephalography (EEG) scans following motor tasks suggest that **Differential Learning** stimulates the somatosensory and motor system,

involving more regions of the cortex than traditional methods of learning by repetition. This happens due to a more extensive stimulation.

Therefore, there is a greater brain activation after performing activities according to the **Differential Learning** approach (which may increase neural impulses and cause better motor performances).

Specifically in football, current research shows higher acquisition rates when using **Differential Learning** compared to more repetitive approaches.

4.7. SCIENTIFIC STUDIES

The first scientific studies on **Differential Learning** were done on simple techniques in sprinting, weight throwing, basketball, volleyball and football. The studies on sprinting and weight throwing showed that athletes reached higher levels of performance, being forced to assimilate or refine their skills. They were able to achieve higher running speeds and greater throwing distances. The studies in basketball, volleyball and football revealed better accuracy in the pass and shot.

Meanwhile, increased noise as an active intervention tool in training was successfully applied in football. Benefits were also found in the use of external noise in motor learning, which corroborated the dynamic system idea of constructive influence interaction, with fluctuations caused internally and externally during learning.

To put these considerations into a quantitative form, we may use the performance improvement per unit of time (where the unit of time can be chosen appropriately, e.g., days, weeks, months, etc.), as the order parameter m (learning rate). The order parameter **m** can capture the bifurcation of **Differential Learning** in terms of transition, such as **m**=0 → **m**>0 (e.g., in a scientific study in the weight throw, athletes improved on average their throw by about 56cm in 4 weeks, thus achieving **m**=14cm/week).

In the training **noise** (control parameter), this will be indicated by the letter **Q**, where training noise will be a measure for the variety of differences between exercises.

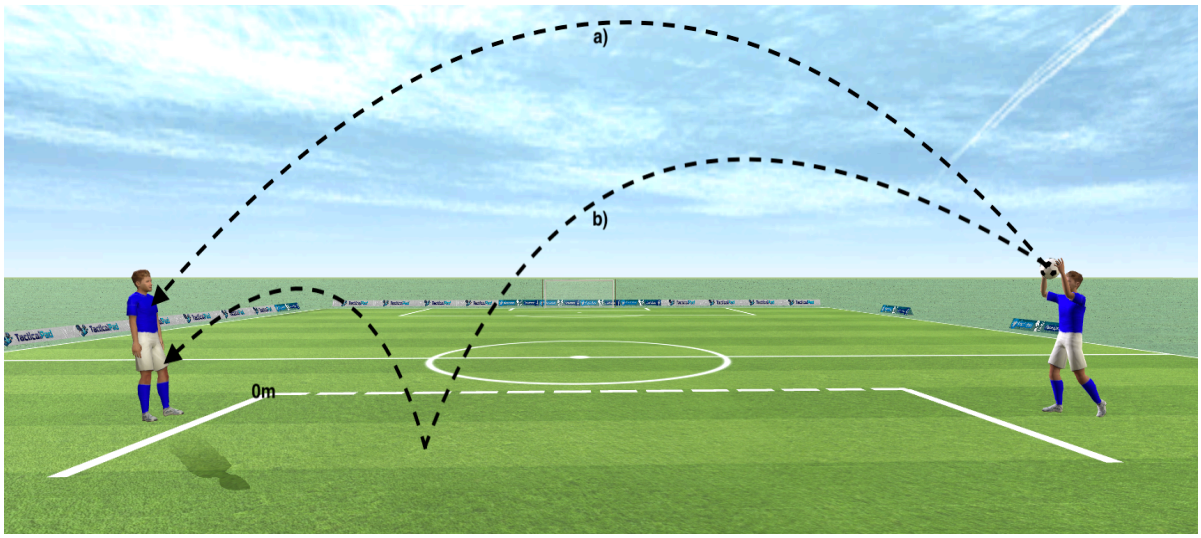
4.7.1. Scientific Studies in Football

i) A study by Schöllhorn, W. I. et al, (2012) looked at the effects of using Differential Training in shooting on goal and ball control situations.

The participants were senior footballers from the lower divisions of the German FA. Three test groups were created (control group, block differential group and random differential group).

The tests performed (pre, post and hold) examined the players' ability to control the ball in as little space as possible and the ability to shoot the ball with accuracy.

In the ball control test, a ball was thrown by an assistant to the participants, in a parabolic trajectory, with the following variants: a) in a direct parabolic flight, at a height that forced the participant to receive the ball with the chest; b) with a short parabolic flight, which forced the ball reception after a bounce on the pitch.



The quality of ball control was established by measuring the distance from the initial contact with the ball and the position where it stopped.

After the pre-test, there was a training intervention over four weeks. The training intervention had eight sessions (two per week), with twenty exercises each day (duration about 12 minutes).

The control group trained according to the classical guided approach, following the archetypes of the ideal movement.

Example of the training intervention (control group):

Receiving the ball with the chest - 10 repetitions. Instructions given by the coach: i) the upper body moves back when the ball reaches the chest; ii) control the ball with the foot on the pitch.

Receiving the ball with the foot - 10 repetitions. Instructions given by the coach: i) minimize the distance between the foot and the ball; ii) step back with the foot when in contact with the ball; iii) control the ball on the pitch.

Methodological sequences of ball control were made with numerous repetitions and corrections of errors.

The main criteria for functional ball control technique were fixing on the approaching ball and a soft first contact with the ball.

The other groups (block differential group and random differential group) trained according to the Differential Learning approach. One group doing exercises with a block order and the other group with a random order in each training session.

Example of the training intervention (block differential group):

Receiving the ball with the chest - 10 repetitions. Exercises: i) Ball reception with the chest (indirect) (r. eye closed + l. arm straight up + r. arm straight lateral); ii) Ball reception with the chest (indirect) (prostrate the standing leg + r. eye closed); iii) Ball reception with the chest (indirect) (feet close together + head nod forward and backward); iv) Ball reception with the chest (indirect) (feet on the inner edge + turn the head to right and left); v) Ball reception with the chest (indirect) (feet cross + tend the upper body to right and left); vi) Ball reception with the chest (indirect) (circle the hip + both arms straight lateral); vii) Ball reception with the chest (indirect) (stand on tiptoe + rotate both arms against the same); viii) Ball reception with the chest (indirect) (feet on the inner edge + rotate the arms forward); ix) Ball reception with the chest (indirect) (feet close together + r. arm close to the body); x) Ball reception with the chest (indirect) (stand on the left feet + rotate both arms forward).

Receiving the ball with the foot - 10 repetitions. Exercises: xi) Ball reception after a throw with ground contact (inner surface + hips back and forth + arms lateral); xii) Ball reception after a throw with ground contact (upper surface +

ball reception wide in front of the body); xiii) Ball reception after a throw with ground contact (exterior surface + ball reception wide lateral of the body); xiv) Ball reception after a throw with ground contact (exterior surface + hips back and forth); xv) Ball reception after a throw with ground contact (inner surface + stand on tiptoe); xvi) Ball reception after a throw with ground contact (inner surface + prostrate the standing leg + upper body to the left); xvii) Ball reception after a throw with ground contact (upper surface + stand insight); xviii) Ball reception after a throw with ground contact (exterior surface + rotate the arms backward + upper body to the right); xix) Ball reception after a throw with ground contact (upper surface + legs hard + rotate the arms forward); xx) Ball reception after a throw with ground contact (inner surface + behind the body + rotate the arms against the same).

Example of the training intervention (randomized differential group):

20 repetitions. Exercises: xvii) Ball reception after a throw with ground contact (upper surface + stand insight); vi) Ball reception with the chest (indirect) (circle the hip + both arms straight lateral); xv) Ball reception after a throw with ground contact (inner surface + stand on tiptoe); ii) Ball reception with the chest (indirect) (prostrate the standing leg + r. eye closed); xi) Ball reception after a throw with ground contact (inner surface + hips back and forth + arms lateral); xvi) Ball reception after a throw with ground contact (inner surface + prostrate the standing leg + upper body to the left); iii) Ball reception with the chest (indirect) (feet close together + head nod forward and backward); i) Ball reception with the chest (indirect) (r. eye closed + l. arm straight up + r. arm straight lateral); xix) Ball reception after a throw with ground contact (upper surface + legs hard + rotate the arms forward) ix) Ball reception with the chest (indirect) (feet close together + r. arm close to the body); xii) Ball reception after a throw with ground contact (upper surface + ball reception wide in front of the body); v) Ball reception with the chest (indirect) (feet cross + tend the upper body to right and left); x) Ball reception with the chest (indirect) (stand on the left feet + rotate both arms forward); viii) Ball reception with the chest (indirect) (feet on the inner edge + rotate the arms forward); xiv) Ball reception after a throw with ground contact (exterior surface + hips back and forth); xiii) Ball reception after a throw with ground contact (exterior surface + ball reception wide lateral of the body); iv) Ball reception with the chest (indirect) (feet on the inner edge + turn the head to right and left); xx) Ball reception after a throw with ground contact (inner surface + behind the body + rotate the arms against the same); xviii) Ball reception after a throw with ground contact (exterior surface + rotate the arms backward + upper body to the right); vii) Ball

reception with the chest (indirect) (stand on tiptoe + rotate both arms against the same).

In the two groups that used the **Differential Learning** approach, the main idea was to increase fluctuations in ball reception to make players more stable in the face of disruptions. This allows the players to explore functional movement patterns. The fluctuations were increased by a multitude of variations in ball reception and by avoiding movement repetitions and not providing corrective feedback. Movement variations were characterised by variations in the supporting leg, arms, upper body and head.

Results:

When comparing the three groups on an individual basis, a significant difference can be noted between the classical group and the two differential groups.

The comparison between the differential groups reveals no significant differences. However, it is interesting to note that the random differential group was exposed to more fluctuations than the block differential group.

Mean test scores (pre, post and retention) of the ball control task:

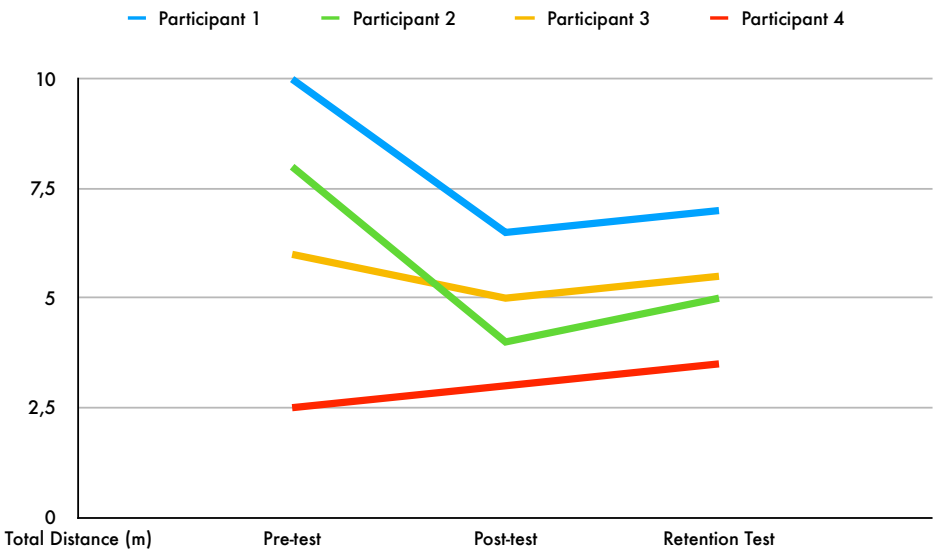
	Pre-test (m)	**Post-test (m)**	**Retention test (m)**
Control group	6,54	4,65	5,06
Block differential group	5,68	4,24	4,18
Random differential group	6,60	4,16	3,93

As the **Differential Learning** approach supports the individuality of performance, the results of each participant are also important from an analytical point of view.

In the classical group, all participants improved their performance in the ball control test between the pre-test and the post-test. Only one participant did not maintain the initial level (he started with an extremely high performance, fluctuations decrease between repetitions, and this makes it increasingly difficult to increase the possible successful solutions). The largest performance increase (45%) was achieved by the participant with the lowest starting level.

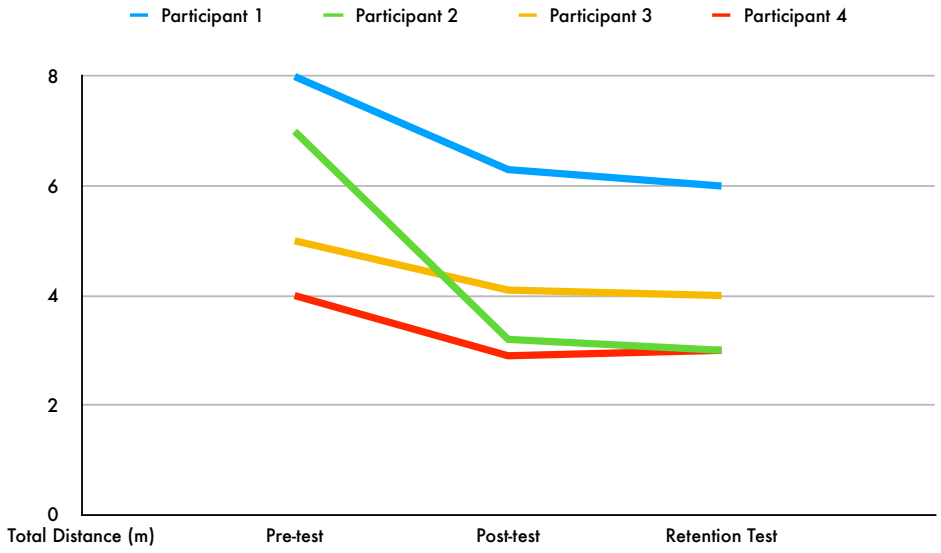
After a two-week break, all participants decreased their results in the retention test.

Ball control test results per participant (classical group):

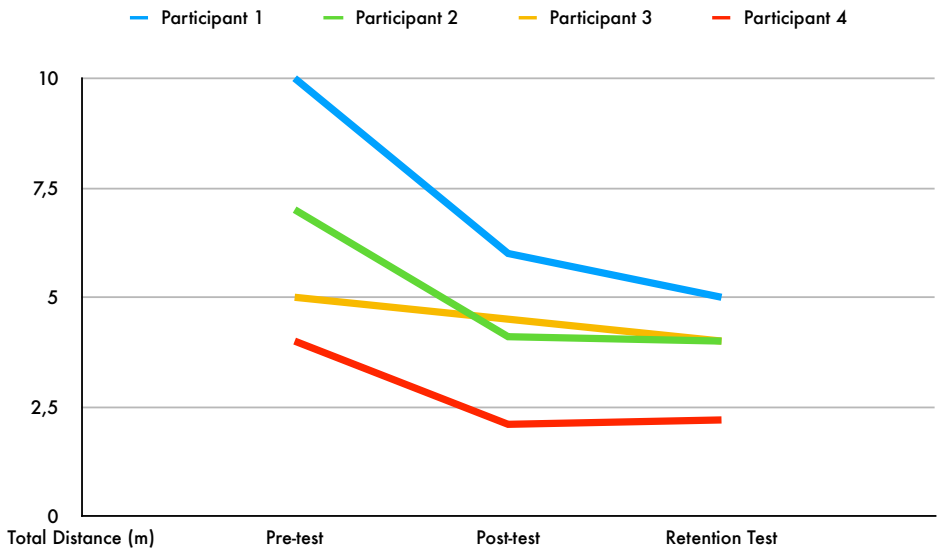


Regarding the participants in the differential groups (random and block), all improved their initial performance from pre-test to post-test. In contrast to the classical group, three out of four participants increased or equalled their post-test performance on the retention test.

Ball control test results per participant (block differential group):



Results of the ball control tests per participant (randomized differential group):



The results indicate that, in both differential groups, most participants improved their performance in all tests after the pre-test (post-test and retention test), regardless of their starting level, indicating further evidence supporting the individuality effect according to the **Differential Learning** approach.

In the accurate shot on goal test, participants shot the ball at the goal without a goalkeeper, from the 16 meters line, in seven different situations. Each situation was repeated five times. The seven different shot on goal situations were: i) Five dead balls were shot towards the goal after a start from position 1; ii) Five balls were shot towards the goal after a 10m drive from position 1; iii) Five balls were shot towards the goal after a 5m drive from position 2; iv) Five balls were shot towards the goal from position 1 after a pass from the right; v) Five balls were shot towards the goal after a 5m drive from position 3; vi) Five balls were shot towards the goal from position 1 after a pass from the left; vii) Five balls were shot towards the goal from position 1 after overcoming a 40cm high obstacle.

The shot accuracy was measured by dividing the goal into scoring zones. The zones were determined according to the scoring probability. Areas that were difficult for the goalkeepers to reach were scored higher and vice versa. Shots that narrowly missed the goal were awarded one point.

The pre-test was followed by a training intervention lasting four weeks. The training intervention consisted of eight sessions (two per week) and twenty exercises each day (lasting about 12 minutes).

The control group trained according to the classical approach guided by the archetypal ideal movement.

Example of the training intervention (control group):

Shot with a dead ball - 10 repetitions. Coach's instructions: i) the support leg stays next to the ball; ii) the shooting leg stays parallel to the ball; iii) the ankle is fixed on the pitch; iv) the upper body stays over the ball; v) the ball should be shot in the centre.

Shot with a live ball - 10 repetitions. Orientations given by the coach: i) the foot of the supporting leg stays beside the ball; ii) the shooting leg stays parallel to the ball; iii) the ankle is fixed on the pitch; iv) the upper body stays over the ball; v) the ball should be shot in the centre.

Methodological shooting sequences were performed with several repetitions and error adjustments.

The criteria for optimal performance in shots on goal included the supporting leg position, the head orientation, the shooting leg width, the maximum speed sequence of the shooting leg, the stiffness of the shooting leg upon contact with the ball, and the arm movement during the approach to the ball and the shooting movement.

The other groups (block differential group and random differential group) trained according to the Differential Learning approach (characterized by never repeating the same movement twice, to find a more complete form and room for more solutions), one group with exercises in a block order and another group with a random order in each training session.

Example of the training intervention (block differential group):

Shot with a dead ball - 10 repetitions. Exercises: i) Goal shot after a short dribbling (inner surface + head to the left and the right + heel off); ii) Goal shot after a short dribbling (exterior surface + full rotation before the shots); iii) Goal shot after a short dribbling (upper surface + r. knee upwards and lateral); iv) Goal shot after a short dribbling (inner surface + r. heel to the back + arms forward); v) Goal shot after a short dribbling (inner surface + rotate arms forward); vi) Goal shot after a short dribbling (upper surface + rotate arms forward + head to the left); vii) Goal shot after a short dribbling (upper surface + rotate arms against the same + head to the right); viii) Goal shot after a short dribbling (inner surface + l. knee upwards lateral); ix) Goal shot after a short dribbling (upper surface + rotate arms against the same + head to the left and right); x) Goal shot after a short dribbling (exterior surface + head to the right +arms lateral).

Shot with a live ball - 10 repetitions. Exercises: xi) Goal shot a jumping ball (exterior surface + run up lateral); xii) Goal shot a jumping ball (upper surface + upper body to the right + run up with little jumps); xiii) Goal shot a jumping ball (inner surface + run up cross + both arms up); xiv) Goal shot a jumping ball (exterior surface + circle the hip + bot arms up); xv) Goal shot a jumping ball (upper surface + both arms forward + hip to the left and right); xvi) Goal shot a jumping ball (inner surface + sidesteps; + head nod forward and backward); xvii) Goal shot a jumping ball (exterior surface + standing leg wide beside the ball + eyes blinking); xviii) Goal shot a jumping ball (inner surface + standing leg before the ball + eyes blinking); xix) Goal shot a jumping ball (inner surface + run up with jumps + arms lateral); xx) Goal shot a jumping ball (exterior surface + upper body forward and backward).

Example of the training intervention (random differential group):

20 repetitions. Exercises: xiii) Goal shot a jumping ball (inner surface + run up cross + both arms up); vi) Goal shot after a short dribbling (upper surface + rotate arms forward + head to the left); iii) Goal shot after a short dribbling (upper surface + r. knee upwards and lateral); xv) Goal shot a jumping ball (upper surface + both arms forward + hip to the left and right); xvii) Goal shot a jumping ball (exterior surface + standing leg wide beside the ball + eyes blinking); xii) Goal shot a jumping ball (upper surface + upper body to the right + run up with little jumps); vii) Goal shot after a short dribbling (upper surface + rotate arms against the same + head to the right); xi) Goal shot a jumping ball (exterior surface + run up lateral); xx) Goal shot a jumping ball (exterior surface + upper body forward and backward); viii) Goal shot after a short dribbling (inner surface + l. knee upwards lateral); iv) Goal shot after a short dribbling (inner surface + r. heel to the back + arms forward); x) Goal shot after a short dribbling (exterior surface + head to the right +arms lateral); xviii) Goal shot a jumping ball (inner surface + standing leg before the ball + eyes blinking); xix) Goal shot a jumping ball (inner surface + run up with jumps + arms lateral); i) Goal shot after a short dribbling (inner surface + head to the left and the right + heel off); xiv) Goal shot a jumping ball (exterior surface + circle the hip + bot arms up); ix) Goal shot after a short dribbling (upper surface + rotate arms against the same + head to the left and right); v) Goal shot after a short dribbling (inner surface + rotate arms forward); ii) Goal shot after a short dribbling (exterior surface + full rotation before the shots); xvi) Goal shot a jumping ball (inner surface + sidesteps; + head nod forward and backward).

The main idea in both groups that used the **Differential Learning** approach was to increase fluctuations in shooting on goal to make players more stable against disruptions. This also allowed players to look for and exploit functional movement patterns. The fluctuations were increased through a multitude of variations in shots on goal, while also avoiding movement repetitions and not providing corrective feedback. Changes in movement were characterised by variations in the supporting leg, the arms, the upper body and the head.

Results:

When comparing the three separate groups, a significant difference can be observed between the classical group and the two differential groups.

A significant difference is only observed between the two differential groups in the retention test, where the performance of the random differential group is significantly better than that of the block differential group.

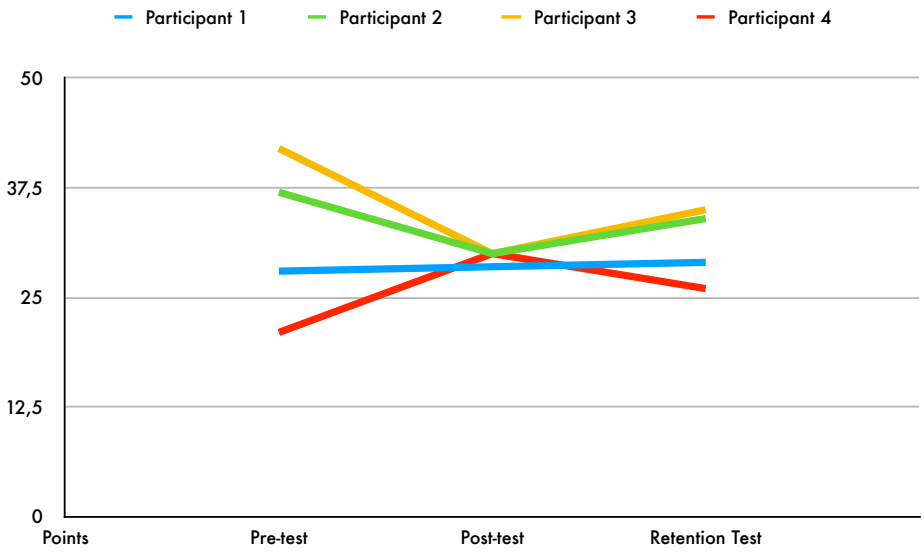
Mean test scores (pre, post and retention) of the goal shooting task:

	Pre-test (points)	**Post-test (points)**	**Retention Test (points)**
Control group	32	29,5	30
Block differential group	32,5	39,8	41
Random differential group	41	42,8	45

As the **Differential Learning** approach supports the performance individuality, the results of each participant are important from an analytical point of view.

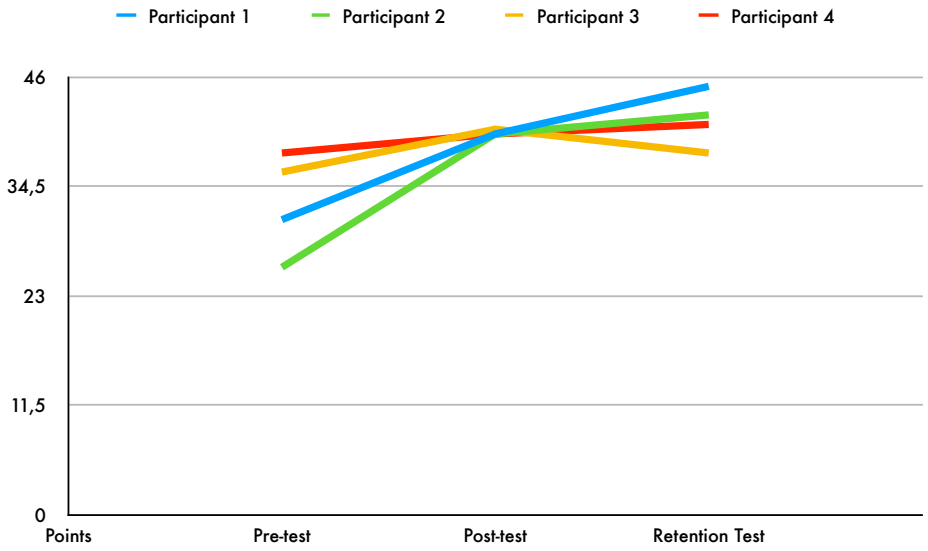
In the classical group, only 2 of the 4 participants improved their performance between the pre-test and the post-test. The other 2 participants decreased their scores compared to the pre-test. Participant 4 had the greatest increase in performance (36%). When comparing the results of the post-test and the retention test, we note that 3 participants improved their performance and 1 participant worsened.

Goal shooting test results per participant (classic group):



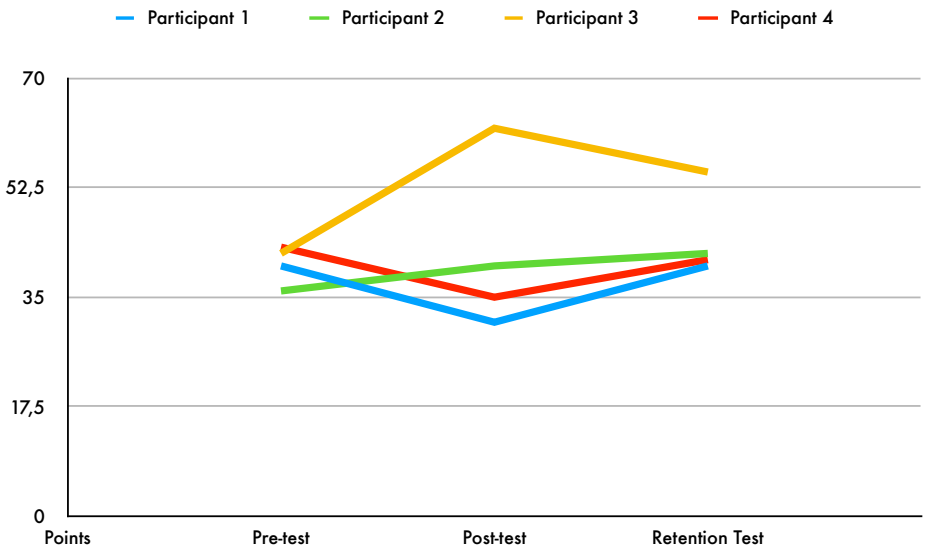
All participants in the block differential group improved their performance in shooting on goal from the pre-test to the post-test. Regarding the retention test, 3 out of 4 participants improved their accurate shot skill.

Goal shooting test results per participant (block differential group):



In the randomized differential group, the results were more heterogeneous. 2 participants improved their performance from pre-test to post-test, 2 worsened. In the retention test, the 2 participants who had worsened their performance between the pre-test and the post-test improved their results between the post-test and the retention test. The participant with the greatest improvement between the pre-test and post-test worsened his performance between the post-test and the retention test. Only 1 participant had a consistent increase in performance (improvement between pre-test and post-test and between post-test and retention test).

Goal shooting test results per participant (randomized differential group):



Conclusions:

This study shows unmistakable evidence of the superiority of the **Differential Learning** approach compared to the classical training approach.

In most cases, in the classical training approach group, an improvement in performance in the acquisition phase (from pre-test to post-test) is followed by a decrease in the learning phase (from post-test to retention test).

In opposition, both groups with the differential approach showed a clear edge in learning the two techniques (ball control and shot on goal). On average, they showed an increase in performance during the acquisition phase and at least maintenance of performance during the learning phase (most participants had an improvement in performance).

There is a tendency to learn and acquire skills when the differences between two consecutive movements are explored during training.

In general, participants with higher initial performance responded better to the **Differential Learning** approach.

The practical consequence of this study is that both techniques (ball control and goal shooting) can be trained using the **Differential Learning** approach.

Due to the non-linearity of motor learning, training with stochastic perturbations is reasonable. Monotonous repetitions of movements should be discarded, while wide variations should be introduced to initiate self-organisation, so that a more effective and efficient learning process can be achieved.

ii) In the scientific articles by Coutinho, D. *et al.*, (2018) and Santos, S. *et al.*, (2018) we have identified the variables that we can modify when we want to implement the Differential Learning approach in football training.

We must sustain training exercises in unpredictable and dynamic environments, which permanently require players to adapt.

Variables to use in training exercises:

- Player's Number: Numerical Relations (1v1, 2v1, 3v3, 4v3, 5v5, etc.);
- Pitch: Playing surface (artificial turf, natural grass, etc.); Shape (rectangle, square, triangle, diamond, circle, etc.); Size (small, medium, large);
- Playing Ball: Size (smaller, normal-size, and larger-size); Type (football, tennis, handball, rugby, reflex ball, futsal, fitball, etc.); Number of balls (one and two simultaneously).
- Targets: Number (1 to 4); Size (small targets (pop-up), 7-v-7 and 11-v-11 targets, etc.); Type of Scoring (stop ball, shot, pick the ball into a box, etc.); Disposition (in the final line, inside and out of the pitch, etc.);
- Field Obstacles: Sticks, ropes, hoop, cones, tchoukball targets, and barriers, etc.;
- Body Constraints: Upper part of the body (Visual occlusion, hands behind head, both arms up, hands tied, rotating arms forward, hands on hips, play with 3D glasses, give touches with a tennis ball on the hand, juggling a balloon, elastic bands, bracelets, players connected with an elastic band, etc.); Lower part of the body (Play with non-dominant limb, with ankles, without trainers, in each ball contact improvise different types of technical skills, etc.);
- Games Rules: Double points if different passes, dribbles, or shoots were performed; Divide the pitch into spaces and limit the specific space allowed to play;

- Combinations: During the game, two or more types of the previous variations were combined.

iii) Also in Santos, S. *et al*., (2018), we may have an idea of some of the methodological aspects to implement the Differential Learning approach in football training.

Nonlinear Causality
0 — 100
- Players perform all movements with consecutive perturbations. - Considered learning progression individually based on nonlinear causality. - Random tasks: 4v4, 2v1, 5v5, 1v1, 3v3, 5v3, etc.
Stochastic Perturbations
0 — 100
- Did not identify key task constraints. - Amplified the fluctuations to promote noise. - Practice tasks: Player performed the pass with their hands tied or with a covered eye.
Movement Repetitions
0 — 100
- Focused on the inter-trial variability of movement patterns. - Movement configurations were changed in short periods of time. - Stress the movement "error". - Practice tasks: constantly improvise new forms to pass the ball.
Corrections
0 — 100
- Without any error correction.

4.8. IMPLEMENTATION IN FOOTBALL: DIFFERENTIAL TRAINING

The goal of **Differential Training** is to help the player to find his individual performance pattern. This depends on the context and the aim is to perform the complex motor skills of this sport as successfully as possible. Therefore, there is no ideal standard of performance. But a subject and context dependent performance pattern.

Context dependence concerns the dependencies of the following parameters:

- Internal (e.g., level of fatigue).

- External (e.g., relative position in relation to an approaching ball).

To help players in this learning process, **Differential Training** consists of training exercises that vary quantitatively and qualitatively from exercise to exercise. In this sense, players are trained through training sequences with "noise".

This training method shows that a constantly changing stimulus encourages the player to understand the differences between exercises and the variety of potential patterns to be performed. By agglutinating the elements of these patterns through self-organisation, the player can find his optimal pattern of performance in each task, in each context, defined internally and externally.

In **Differential Training**, players are usually instructed to actively perform movement errors (e.g., shooting with the supporting foot away from the ball instead of beside it). The key aspect is to get players to perform a process of self-organization that will produce an individual context-dependent optimal performance pattern.

4.8.1. Differential Learning System - Football (Ball Receiving)

Wolfgang Schöllhorn shows us in "**Differential Learning** System (DLS) Drills Package: Ball Receiving", some possibilities to implement when we want to train Ball Reception with the **Differential Learning** approach.

Division into three categories:

1. *Variation of the contact surface*:

- Foot (low balls) - inner, outer, heel, instep and sole of the foot.
- Foot (high balls) - inner, outer, instep.
- Thigh - from above, from the outside, from the inside.
- Chest - receive the ball with the chest and put it on the ground quickly, receive the ball with the head, receive the ball oriented to one side.

2. *Variations with the shooting leg*:

- Bend the knee; Leg fully extended; Long contact with the ball; Short contact with the ball; etc.

3. *Variations with the support leg*:

- Too far back from the ball; Far ahead of the ball; Sideways away from the ball; Play seated; Play kneeling; etc.

4.8.2. Ralf Rangnick's Exercises

Ralf Rangnick has created some exercises which "mess" with the shapes of the playing field, and which fit perfectly in the **Differential Training** approach.

i) Ping-Pong Game:

- This game takes place in depth, in a long and narrow "tube". The number of footballers varies (teams of 4 or teams of 5 footballers). The objective is to move the ball from one end line to the other.

- Neutral supports in the side areas are extra footballers, who will add numerical superiority to the team with the ball. When the ball is recovered, superiority is exchanged. The attacking team must first make a front one-two (dynamic from

the 3rd man or from the 1st to the 2nd, who passes the ball back to the 1st) with the neutral support in depth to score a goal. The neutral support in depth who receives the ball passes it directly with 1 touch or with 2 touches at most. The game should take place with the least number of touches to avoid delays and to prevent the outnumbered team from advancing and blocking the gaps.

- Alternatively, limiting the number of touches can be done through the "2-1 rule": if a footballer uses 2 touches, the next teammate must pass the ball with one only.

- For the footballers, it will be a challenge to find support points in this narrow corridor.

- With this way of playing, it will be possible to develop perception, orientation and pressure, increasing the footballers' cognitive abilities.

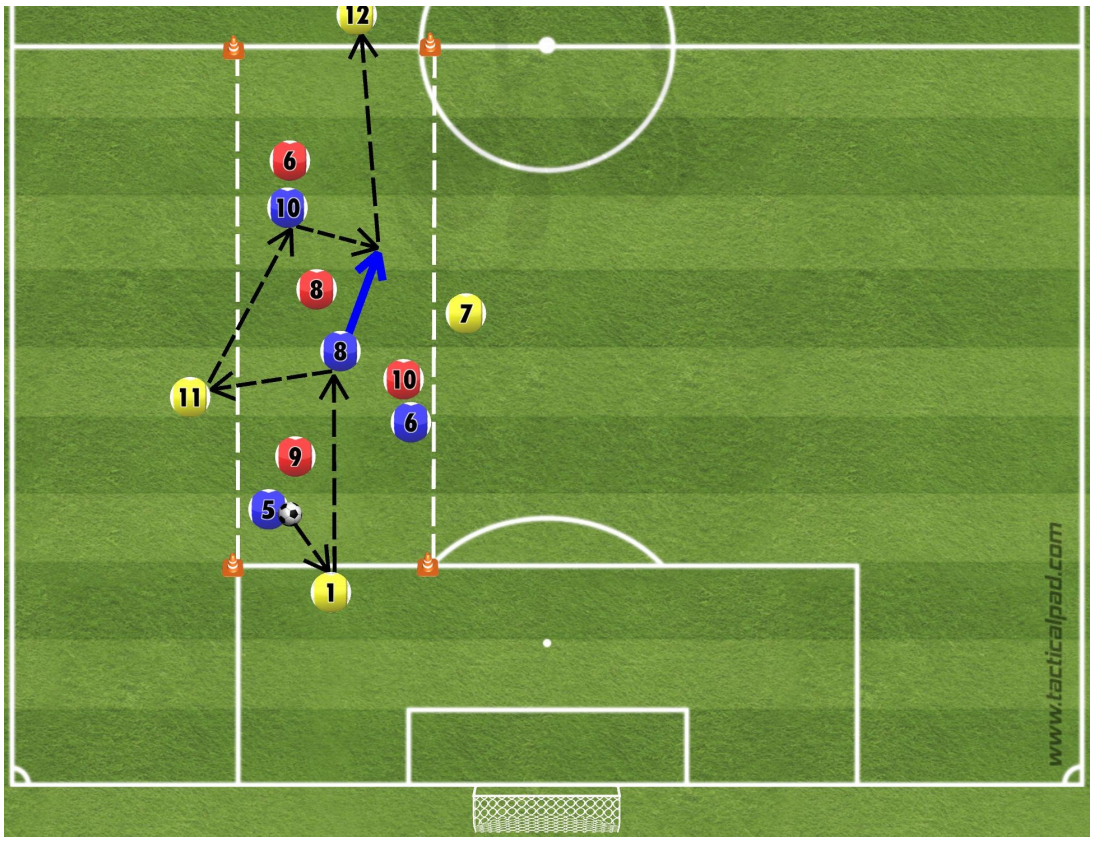
Organization and Procedure:

- Deep pitch with an approximate size of 12x36m.

- 4v4 game with 4 neutral supports. The 2 footballers positioned in depth (on the short sides of the playing field), to facilitate the deep frontal play, are the target footballers, creating a clear direction of play. The 2 footballers positioned wide (on the long sides of the playing field) increase the numerical superiority ratio of the team with the ball.

- The one-two with a deep support (target footballer) awards a point to the team that manages to do so.

- Depending on the version chosen (footballers "tactically placed" or not), the game may continue with or without interruption.



ii) Game on a Trapezoid-shaped pitch:

- This "5v5+GK" begins with the forwards positioned across the width of the box, with the pitch narrowed to the semicircle width. The neutral supports are positioned on the sides and on the narrow patch. Therefore, the forwards, together with the 4 neutral supports, have a clear numerical superiority (there is a 2-touch limit or the "2-1 rule"). The neutral supports can only move between the posts that delimit the range of action (on the outside of the pitch). Initially, the neutrals may touch the ball twice, but it is preferable that they play only with 1 touch to give less time to the other team's defenders.

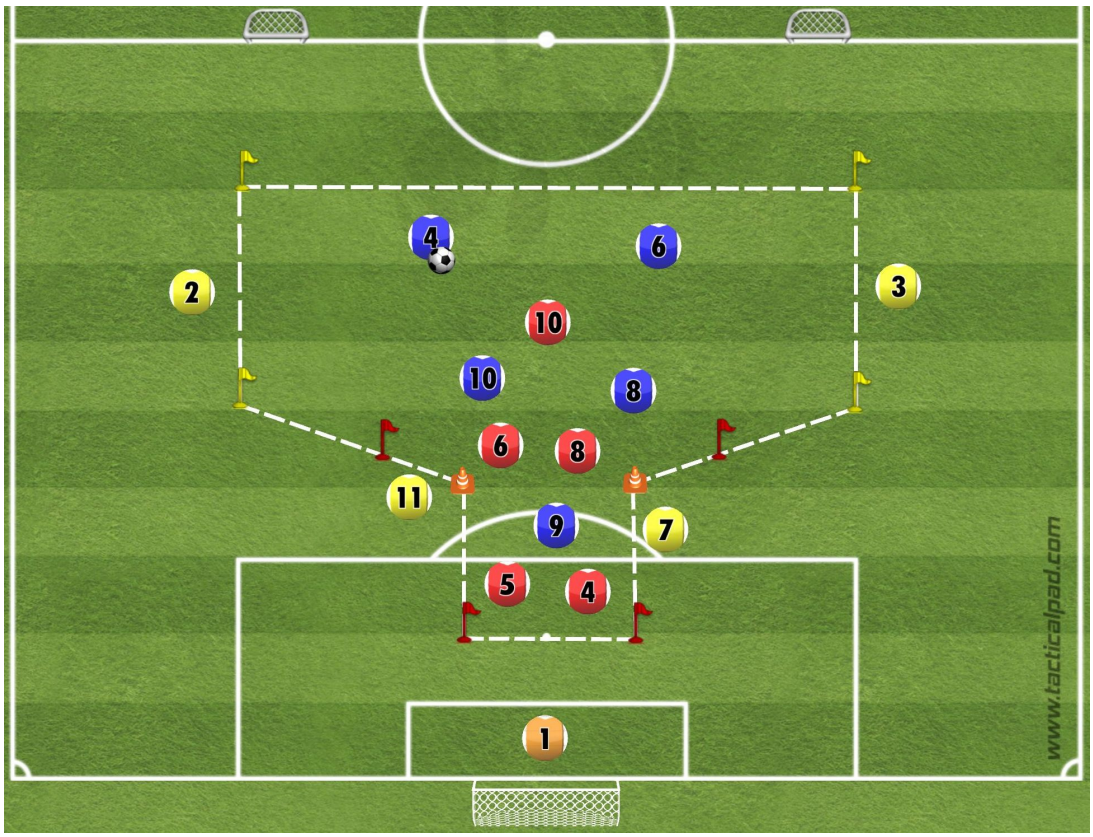
- To finish plays (within the narrow pitch zone), several touches are allowed for the forward to score (e.g., if he must overtake an opponent).

- The purpose of this is to make the attacking team have a vertical and deep game and, after losing the ball, immediately exert pressure to recover it. The team defending the goal with Goalkeepers, after recovering the ball, must quickly find the mini nets, attacking deep, to execute the intended

counterattack after recovering the ball. To do so, they must transition quickly after recovering the ball and prefer depth to width.

Organization and Procedure:

- The pitch runs from the penalty spot to about 11m from the midfield line. The pitch bottleneck is about 12 m wide, and the longest section of the pitch runs to the side line of the box.
- Within the playing field, a 5v5 is played. The attacking team narrows its game to score in the goal defended by the goalkeeper and the defending team, after recovering the ball, counterattacks towards the 2 mini nets located in the midfield line.
- The neutral supports assist the attacking team outside the playing field but are limited to the respective flags.



iii) Game on a "Banana Pitch":

- The boundary of the narrowest corridor depends on the team's abilities. At the beginning it may be narrowed down to the goal kick mark and progressively we may reduce the width of the pitch to the edge of the centre circle.

- The widest part of the pitch is bounded by the line furthest from the box. When setting up the teams, it makes sense to place the footballers on the left side of the pitch, playing from bottom to top, and the ones on the right side playing from top to bottom. Two neutrals are placed in the midfield line. They can move between the "two offside lines". The offside lines in the centre of each half are important. If the offside line were in the midfield line (according to the official rules), only pressure would be applied, and the vertical play would receive scant attention. With this change in the rules, the footballers are forced to play vertically, because the possibilities to transition and to advance on the pitch are much more difficult, almost impossible to accomplish given the narrowness of the pitch.

- In case there are more footballers in training, we can use a "double banana". In other words, the same layout on the other side of the pitch, in a 5v5 with 2 neutral supports on each side. If the game is played in a single "banana", from the Goalkeeper build-up to the scoring play, the footballers in the other "banana" take a break (this is an effective way to control the load). If we want to reduce the load further, we can shorten the pitch and place the goalkeeper on the edge of the box.

Organization and Procedure:

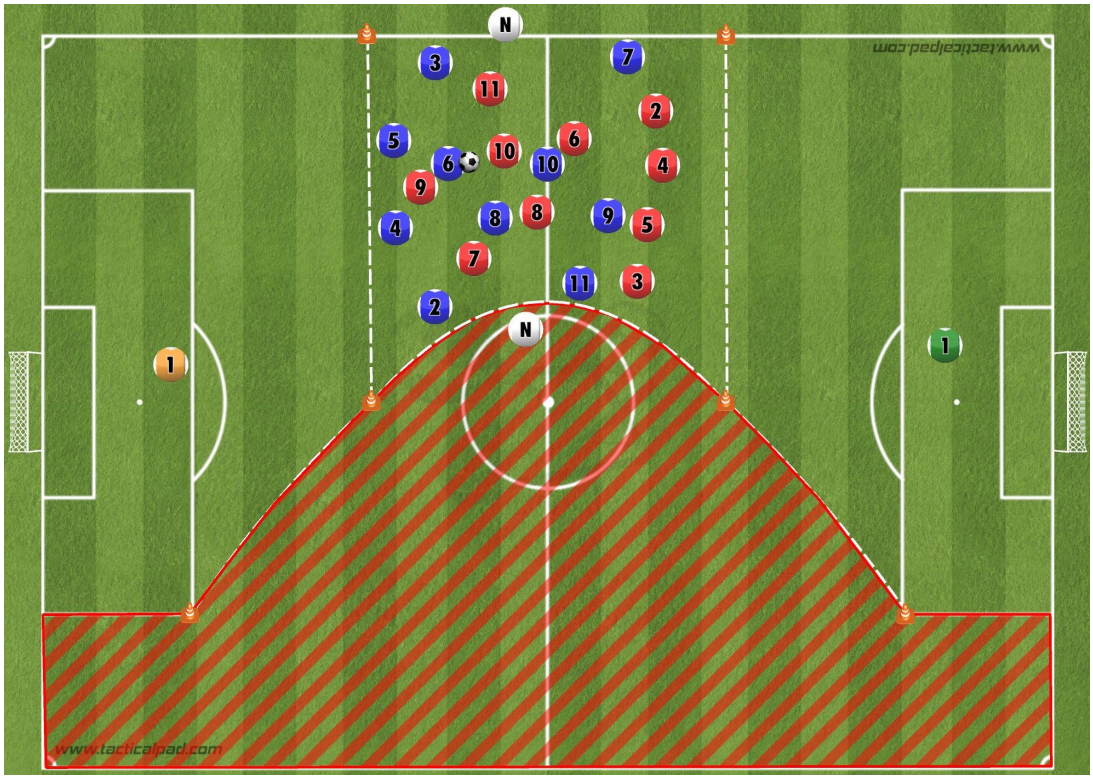
- Shorten the pitch from the width of the penalty box, placing the centre circle completely outside. As a variant, we can also shorten the pitch to the goal kick spot (simplification) or adjust the width of the pitch according to the teams' skill.

- GK+10v10+GK on a "banana pitch". The two neutral supports play with the attacking team.

- Offside lines in the middle of the two halves: no offside in the central pitch area. This makes it easier to play in depth; if normal offside was applied, it would be almost impossible to create play in depth.

- Objective during the build-up: building up down the side corridor, "play through the needle hole" with deep passes. Under this model, a long game with a long build-up is impossible.

- The defensive objective during the build-up: immediate pressure after losing the ball. Using the space and footballers close to the ball, immediately searching for depth when the ball is recovered..



iv) "Hourglass" Game:

- This game is based on the idea of shortening the pitch to encourage playing in depth. Footballers are forced to look for vertical plays and have the courage to make vertical passes.

- This may seem like a risk at first sight, but it happens in top-level matches. In those, the passing windows are sometimes only one metre wide and are open for half a second. If the footballer does not have the vision and courage to pass the ball quickly through this "window", it will be quickly closed.

- *CounterPressure* in the game against the ball is an ideal complement to vertical play with the ball. Regarding this, Ralf Rangnick quotes Jurgen Klopp, who implemented this at Borussia Dortmund: "no stray passes!". Even if the vertical pass "through the window" is intercepted by the opponent, we will have superiority in the areas near the ball and can try to regain possession quickly. Accordingly, the opponent who has won the ball must experience pressure at first.

Organization and Procedure:

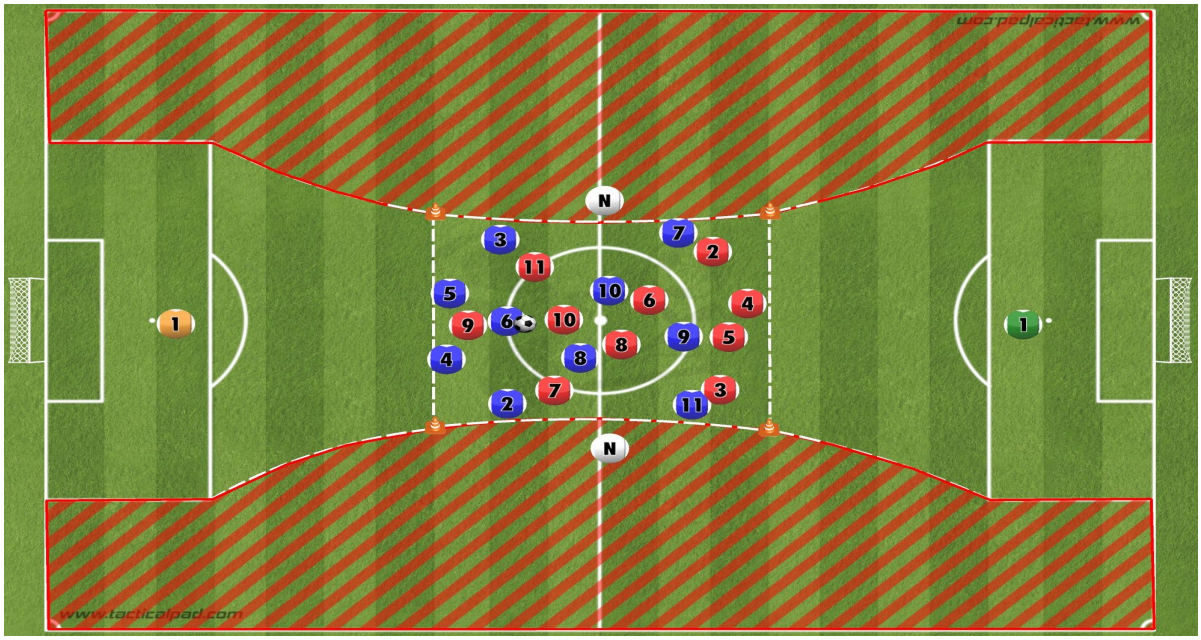
- The pitch includes the boxes, and it narrows from there, reaching a width of about 20m from the midfield line.

- The game is played in a GK+10v10+GK, with 2 neutral supports at the sides of the pitch and with the team having the ball.

- An offside line is marked in the middle of the two halves.

- Objective with the ball: build-up with vertical passes to the top, courageously taking advantage of the "windows".

- Objective without the ball: immediate recovery after misplaced passes, followed by a quick attack on goal within 5 seconds.



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5. TEAM BUILD-UP

Thomas Tuchel believes that the coaches' role is to guide footballers and help them play as a unit.

To build a football team, a clear distinction must be made between the "***How***" and the "***What***".

The coach must take full responsibility for the "***What***".

i) What are we going to play?

ii) What rules are we going to play by?

iii) What tactical system will we use?

iv) What footballers will start the match, etc.

Coaches should analyse the opponents and reveal their strengths and weaknesses. They should also choose the tactical system for the match and possible modifications. The coaches work depends a lot on the relationships within the club (with the footballers and other staff). The goal is that everyone reaches their highest potential to bring joy to the supporters (who should get excited about the performances, the victories and silverware).

But footballers must respond to the "***How***".

Footballers must solve situations (in training and especially in matches). This "***How***" is the essential glue that holds everything together, especially in the competitive world of football. Executing things is what determines success, making the difference between winning and losing. Footballers must take full responsibility for the "***How***".

The "***How***" is more important than the "***What***".

At the highest level, Thomas Tuchel is convinced that football is a "footballers' game" and not a "coaches' game". For Thomas Tuchel, football is a "coaches' game" only in the U15 to U18 categories, where the coach can win and guide the game with significant impact. Therefore, the role of coaches and staff is to be at the service of the footballers. They should be a supportive and helpful resource. Coaches should not leave footballers alone; they should support them and define the rules of collective functioning. These rules will be fundamental for the functioning of the group and the daily coexistence. They are adapted to the

group and detailed by the coach or the footballers. Then, these collaborative rules are displayed where footballers spend most of their time in the training centre: the locker room! These rules address how everyone should greet each other, with the aim of fostering a positive and trusting environment (everyone should look each other in the eye).

For example, at Mainz 05, Thomas Tuchel has created a "scorebook" to promote a good atmosphere and to ensure full commitment of the footballers during training sessions. Before each session, all footballers had to add their signature (forty-five minutes before the session started, the book was taken out of the locker room by one of the coaches). There were no exceptions. Anyone who did not do so was fined €50 (increasing by €50 whenever the signature was not made). With that signature, footballers assured their mental and physical availability, committing themselves to compete, to be completely focused on the training session in a meaningful way. Other rules created by the footballers included no mobile phones and other electronic devices in the training facilities, no "revenge" fouls in training, no disapproving gestures by the footballers (e.g., with the hands) and no discussions with the staff (after the training session the footballers could talk and discuss with Thomas Tuchel about everything, but not during the training session). These rules also required footballers to train to the maximum (train in the same way as they play).

6. CONSTANT LEARNING

Thomas Tuchel and his staff are constantly learning, looking for inspiration from the best (in any area of knowledge). This can happen through readings, reports, trainings, etc. For example, they wanted to know in detail Pep Guardiola's FC Barcelona, Dirk Nowitzki's (basketball) routines or THW Kiel's (handball) weekly planning. Repeatedly, they came across the great humility of these top performing examples. Humility in the effort to achieve top-level performances. They also always noted the total commitment of all involved, who humbly accepted their role within the team.

Kurt Helin showed NBC Dirk Nowitzki's warm-up routine before the games. He began by saying that Dirk Nowitzki's shots always seem to go in, regardless of how oddly shaped his body position is. It seems like he's prepared for anything.

And that's because his training routine prepares him for everything.

That routine initially consists of typical shooting drills, but then the madness escalates to the point of freakishness.

Free throw line pirouettes, 360º rotations on one shoulder followed by a shot and then the other shoulder. We got dizzy just watching it.

Shots supported on one foot only, right or left; both with the leg extended or the knee bent at various angles; using the backboard or not.

These and other unconventional shots prepare him for the unconventional in all games.

7. CREATING A SPECIAL ATMOSPHERE

For Thomas Tuchel, all successful teams have a special atmosphere and a great daily bond within the locker room.

The German coach promotes big celebrations during training sessions. For him, these celebrations can make the difference in creating a bond. This brings the footballers together and creates a good atmosphere in the locker room.

During a Chelsea FC pre-season training, Thomas Tuchel divided the players into two teams. The one who scored more headers would win. The loser had to sing a Backstreet Boys song in front of the others at night before dinner.

The training ground is the best place for everyone to get to know each other.

7.1. HOW TO MOTIVATE GREAT FOOTBALLERS?

For Thomas Tuchel, knowing what drives a footballer is crucial. We need to find the boy with the ball under his arm, the person he was before becoming the superstar. We must be direct and straightforward with them. And create a good connection and give them responsibility.

We must create a "family", where the coach should be friendly every day, but where he is not just another one of the footballers' friends (it is an exceptionally fine line that is established with the footballers).

Footballers (especially the high-level ones) need a clear image of what they are supposed to do. They need freedom to express creativity in their space (the coach must create conditions so that they are protected in those moments).

The best way to get to know footballers is at the training ground (character and talent).

Significant importance is given to players' attitude (to buy them or to play them on matches)

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