A Constraints-Led Approach to teaching climbing techniques: comparison between a non-linear pedagogical approach and a traditional one

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Resume

The “Constraints-Led Approach” (CLA) in recent years has been the subject of interest and study by many researchers and pedagogists, proving to be an excellent teaching method for teachers and coaches in the sports field. This pedagogical approach is based on the principles of so-called “non-linear pedagogy” and articulates that through the imposition of certain constraints related to the task, subject or environment; the learner will develop a personal motor solution with the aim of completing the motor task (Renshaw & Chow, 2018). In order to use this pedagogical approach correctly, however, it is necessary to know the theoretical bases relating to skill acquisition, skill learning, models and adaptations to learning and how to measure the latter.

The task that this master's thesis therefore set itself is first and foremost a bibliographic review of all the topics mentioned above. In addition, with the purpose of verifying its practicality of use and effectiveness, the principles of CLA, were applied to a teaching program of three lessons; with the intent of teaching basic climbing techniques to a group of beginners (n=3), and compare it with traditional teaching methods applied to a second group (n=3).

The results obtained using retention and transfer tests (Adams, 1987), showed that CLA is easily applicable to a sport such as climbing. However, probably due to the limited time of application of the intervention and the limited sample, the “Constraints-Led Approach” was not able to prove more effective than a traditional methodology.

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1 Introduction

In recent decades, the landscape of physical education and sports training has undergone a profound evolution, shifting the focus from traditional teaching approaches, based on technical repetition and the transmission of ideal motor models, towards more dynamic and learner-centered models and the learning environment.

In fact, since the beginning of the ’80 years, motor skills, at school as well as in non-school sports contexts, were taught using pedagogical approaches dominated by technique, which overestimated the effectiveness of the isolation of motor skills, the breakdown of tasks and the repetition of the aforementioned techniques in order to acquire the skill and its transfer into actual game or performance situations (Rink, 1993; Chow et al, 2007).

From the years 2000 onwards however, researchers began to understand the fundamental role of decision-making, of cognitive process and intentionality, based on the new findings in ecological psychology, thus turning towards more dynamic teaching and learning models (Chow et al, 2007). It has therefore become of fundamental importance to involve students and athletes in contextualized activities, in which the relationship between body, environment and task is the core of learning and of the acquisition of motor skills, thus overcoming the idea of a single ideal executive model that is the same for everyone. Individuals can then take advantage of the enormous variety of movement possibilities offered by the human musculoskeletal system to vary the ways in which they solve motor problems (Chow et al, 2007), adopting personal solutions according to the situation and task demand.

In this new theoretical context, physical education coaches and teachers essentially become designers of learning environments: to improve preparation for sporting performance, teaching and training methodologies must be designed in such a way as to allow athletes to exploit learning opportunities that foster innovative and adaptive performance behaviours (Correia et al, 2018).

Given these premises, the task undertaken by this master's thesis is to review the bibliographic sources regarding the topics of skill acquisition and skill learning, as well as explain the concepts underlying pedagogical approaches defined as non-linear, with particular attention to the “Constraints-Led Approach”.

1.1 Skill acquisition

According to Bernstein (1967), the acquisition of a skill is seen as "...the process of mastering redundant degrees of freedom of the moving organ, in other words its conversion to a controllable system". The motor system of the human body is in fact able to solve a problem, to develop a skill, through the management of degrees of freedom, i.e. the numerous movement possibilities offered by muscles and joints. The author points out how beginners often use the strategy of "freezing degrees of freedom": they try to stiffen some joints or make them move in a synchronized way, reducing the complexity of the motor task in order to be able to complete it. To give an example, in tennis, to hit the ball with the racket, a beginner usually freezes the elbow and wrist joints, using the entire arm as if it were a single segment. With practice, however, it is then possible to thaw the joints, allowing a more coordinated, more fluid and intersegmental execution of the movement. However, Newell and Vaillancourt (2001) point out the possibility of increasing or decreasing the complexity of motor control during learning, adapting the constraints that are imposed by the task on the performer.

Based on these statements, we can easily comprehend that the core that must be fully understanded is the relationship between performer and environment.

Key characteristics of the executor-environment system, that constrain abilities, include the structure and physics of the environment, biomechanics, morphology, emotional and task-specific constraints. Everyone therefore interfaces with these constraints, trying to exploit and satisfy them, in order to achieve the objectives required by performance (Davids et al, 2013). To be successful in this arduous task, athletes have multiple operating models at their disposal, based on the concept of "degeneracy", i.e. the ability to implement functionally equivalent actions but through a different use of their perceptual and motor systems (Edelman & Gally, 2001; Mason, 2010; Withagen & Michaels, 2005). This phenomenon has been empirically demonstrated thanks to various studies in football and basketball which have showed how different subjects use their bodies, body segments and joints, in different ways, to satisfy the demands of the same motor task such as a shoot in football for example (Davids et al, 2013).

With the aim of identifying the precise characteristics necessary to help the skill acquisition process, the so-called "SPORT framework" was created (Farrow & Robertson, 2017). This model lays its foundations on five main features set out below:

1- Specificity= defined as the grade the practice performed (the training) reflects the demands experienced in competition. This characteristic is essentially based on the concept of "representative learning design", which explains how the constraints of training and practice must adequately replicate the performance environment, in such a way as

to allow athletes to “detect affordances for action and couple actions to key information sources within those specific settings” (Pinder et al, 2011). Specifically, the constraints to which the author refers belong to three categories: individual constraints, namely the physical and psychological characteristics of the athlete; environmental constraints, namely the conditions of the field or even weather conditions; and task constraints, namely the skills to be performed, the rules of the sport or the equipment used.

2- Progression= defined both as the athlete's improvements but also as his ability to tolerate an increasing load. This increase in load can refer to an increase in volume, a greater technical rate, a higher representativeness of the practice (closer to the performance in the race) or a greater mental commitment.
3- Overload= understood as cognitive effort, that is, the mental work required by the decisions that guide the movement, which can refer to the resolution of a specific technical problem related to the execution of the gesture or the processing of information to make decisions in complex environments. In fact, it has been shown that a practice that requires high levels of cognitive effort can lead to lower performance during training, but better retention and transfer of the learned ability; while low cognitive effort practice leads to high performance in training, but worse retention and transfer.
4- Reversibility= defined as the principle due to which athletes lose the beneficial effects of training the moment they reduce the activity or pause it.
5- Tedium= defined as boredom, a state of monotony that generates disinterest and a reduction in adaptations to stimuli, which is harmful to any training program. In this regard, the concept, first introduced by Bernstein (1967), of “repetition without repetition” can help, which points out that no movement can be identical to another due to its complexity and variability, caused by environmental circumstances that the subject finds himself facing. It is therefore more advantageous, also thinking about the concept of overload explained above, to explore one's motor repertoire, investing in a greater mental effort required by environmental complexity and variety.

1.2 Skill learning

However, the acquisition of a skill is only the first step, and it is for this reason that when one wants to refer to the entire process, one speaks of “skill learning”. Learning is defined as a change in a person's ability to perform a skill, as a result of practice or experience (Magill & Anderson, 2010). However, this process cannot be observed directly but only deduced from

some characteristics of a person's performance, i.e. from his execution of a certain skill at a certain time and place.

When learning a skill, six performance characteristics are generally observed (Magill & Anderson, 2010):

1- Improvement= over time a person is able to perform a skill at a higher level than at an earlier time. It should be underlined that it is possible for stalling or regression phenomena to occur, but they are part of the learning process and improvements must be observed on large time scales.
2- Consistency= as learning progresses, performance becomes increasingly consistent, which means that, from one attempt to another, a person's performances tend to be more similar.
3- Stability= performance becomes more stable as the individual progresses. Internal and external perturbations, such as stress or environmental modifications, affect the execution of the skill less.
4- Persistence= understood as the ability to maintain the improvement acquired through practice over time.
5- Adaptability= a person can perform a certain skill in different contexts.
6- Reduction of attentional demand= the increase in practice and its learning and improvements, lead to a reduction in the amount of attention needed to perform a certain skill.

1.3 Learning models

Now that the characteristics of learning have been defined, we need to move on to the learning models that have been identified and proposed by researchers over time.
The first model was proposed by Paul Fitts and Michael Posner in 1967, who identified 3 stages of learning a motor skill:

1- Cognitive phase= is the phase in which the beginner focuses on what to do and how to do it; asking questions like “what is my goal? How should I move my arm? And if the leg is in this position, what do I do?”. At this stage the performer does many mistakes, and the performance is highly variable, with very little consistency. The subject can usually understand that he is making a mistake but does not know how to remedy it.
2- Associative phase= with practice and improvement the subject manages to connect specific environmental clues with appropriate movements, to complete his motor objective. Errors become less severe and less frequent, showing some consistency.

3- Autonomous phase= is the final phase, in which movement and motor skill become automatic, and the subject is able to perform it autonomously without thinking consciously about the movement anymore. At this point he/she can carry out the motor task even by doing other tasks at the same time, and he/she is able to recognize the mistakes he/she is doing and correct them.

A second model often used in scientific literature is the one from Gentile (2000), in which only two stages of learning are identified. The first phase is referred to as the initial phase. At this moment the beginner aims to acquire a movement that allows him a certain degree of success, respecting the so-called "regulatory conditions" of the environment. They are for example, giving the example of the gesture of grabbing a glass containing water, the size and shape of the glass, its position, the type of liquid etc. The second objective then becomes to distinguish the regulatory conditions from the "non-regulatory" ones, i.e. everything that does not directly influence the execution of the movement, such as, the colour of the glass or the shape of the table. In the second and final phase, the subject must focus on three different aspects: adapting the movement to the specific requests of different situations, improving its consistency and learning to perform the motor gesture in the most economical way possible. It should be underlined that, regarding closed skills, the objective is always perfection, the fixation of the motor pattern in its best possible version, while for open skills the final objective is the ability to adapt the motor pattern to environmental changes in such a way as to be able to reproduce it in any type of context.

Even Bernstein in his book "*Dexterity and Its Development*" (1996), proposed his own learning model, even comparing it to a 7-phase play, a simile that perfectly conveys the idea of how difficult it is to learn a skill.

1- First phase= the decision on which system level of "motor control takes the lead" in performing a motor gesture. According to the author, it is level D, the actions' one that takes control; followed by level C, which is the coordination one, that depends on the external environment; then level B, the organization of muscle synergy; and finally, level A, the regulation of muscle tone
2- Second phase= development of a plan or strategy to address the motor problem
3- Third phase= identify the best sensory corrections
4- Fourth phase= the chosen corrections are performed and automated without conscious control
5- Fifth stage= seeking harmony between the initial movement and the different corrections put in place

6- Sixth phase= standardization of movement
7- Seventh phase= stabilization of the movement, which becomes resistant to any type of disturbance or environmental change

A final, more recent model is the one proposed by Renshaw and Chow (2018), which is an adaptation of the three-phase model that was proposed by Newell in 1985. The two authors identify two phases: a first one, called the coordination learning phase which concerns research and exploration to develop coordination schemes between the individual and the environment; and a second, called the adaptation phase, in which the focus shifts to performance optimization, "through developing stable yet flexible coordinating structures based on the emerging ability to exploit the individual-environment system" (Renshaw & Chow, 2018).

1.4 Adaptations to skill learning

Initially, when a beginner finds himself learning a new skill, he always tries to associate it with a skill he already knows, looking for similarities with the purpose of meeting the requirements of the motor task. For example, a baseball player struggling with golf will always try to swing from the motor coordination he knows to perform from baseball (Magill & Anderson, 2010). Once the demands of the new motor task and the needs of the new skill have been understood, the transition period begins, in which the subject tries to adapt the already assimilated motor scheme to the needs of the new objective. During this phase, which can often be very frustrating, the kinematics of the limbs are irregular and unstable, due to new coordination requests.

The first phenomenon that occurs is the greater involvement of the muscle groups involved in the movement, which are often activated with incorrect timing and with an intensity greater than necessary. In addition, the motor gesture is performed with excessive awareness, the person thinks about every part of the skill, placing the focus on too many aspects at the same time, often also on irrelevant external stimuli. Only after a lot of practice the motor gesture become cheaper and more efficient; the person learns to pay attention only to useful information, making movement more automated and learning to recognize and correct any errors (Magill & Anderson, 2010).

Furthermore, from a neuronal point of view, the researchers, thanks to the use of neuroimaging technologies, observed that in the initial stages of learning the most involved circuit is the cortico-cerebellum-thalamo-cortical one, with the participation also of the striatum, the cerebellum and some specific areas of the motor cortex. On the other hand, during the execution of an already established ability, it is the basal ganglia that is mostly involved: in particular the

putamen, the globus pallidus and the inferior parietal lobe of the cerebral cortex (Magill & Anderson, 2010).

1.5 How to measure learning

After summarising what the scientific literature enunciates about learning, it is necessary to understand how it can be measured. Over time, three different methods have been identified. All of them, thanks to the measurement of performance over a prolonged period of time, can give an indication of the learning of a subject. Here below, three examples are given and explained by Magill and Anderson, in their book "*Motor learning and control*" (2010).

The first method is the learning curve. This methodology involves measuring a specific performance at different times, during a given period. Putting the obtained data into a graph we can get a curve that can follow four main trends, shown in figure 1:

- Curve "a" is a linear curve indicating proportional improvements over time.
- Curve "b" is a negatively accelerated curve, indicating a large improvement early in practice, with smaller improvements in later stages.
- Curve "c" is a positively accelerated curve, i.e. the opposite of curve "b". It indicates a modest improvement at the beginning, followed by a substantial increase in the final part of the practice.
- Curve "d" is called S-shaped, and it is a combination of the previous three curves.

It is important to underline that these four types of curves are purely theoretical and have the sole purpose of clearly showing the different trends. A learning curve usually looks more like the curve represented in Figure 2; in which we can see that the performance measure is the root-mean-squared error (RMSE) for each trial, which tells us that over time the performance is better because of less errors.

Figure 1

Four general types of learning curves

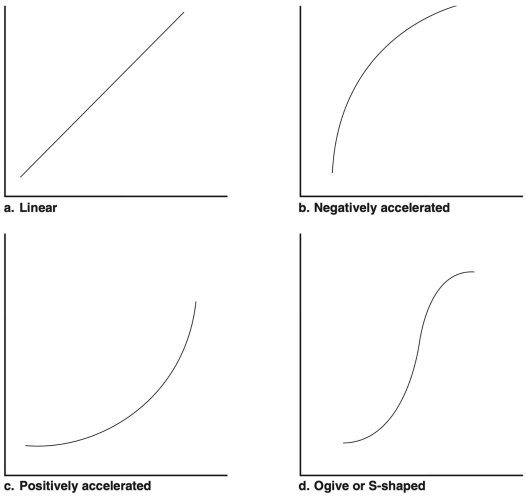
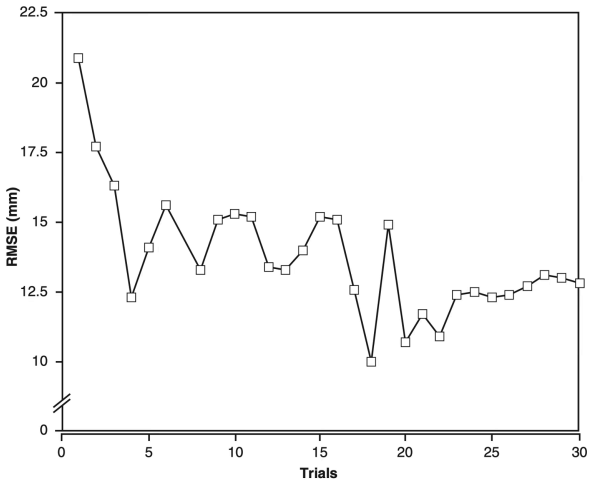


Figure 2

Performance curve of a person learning a pursuit tracking task.



A second possible method is the use of the so-called "retention test", thanks to which the permanence or stability of a certain level of performance obtained thanks to practice is determined. It consists of having the subject perform a certain skill he has learned, after a period off from practice. The person, therefore, performs the same motor task in the same context he used to train in during the learning phase, or in a very similar context (Adams, 1987). The duration of the interval between the end of the practice and the test is arbitrary, but it should be long enough to allow the effects of the performance variables to vanish, so as to determine what has actually been learned.

The third method is the "transfer test", which evaluates the ability of the learner to adapt. In this case, a new situation is proposed, a new context, in which it is necessary to adapt the practiced skill, in order to complete the motor task. Another possibility is to have the individual perform a variant of the skill itself. This test can then include changes to the environment, task, or directly to the subject (Adams, 1987).

A final observation to be made, entering more into the perspective of non-linear pedagogy (a topic that will be covered in the next paragraph), is the importance of creating evaluation tests composed of evolving tasks: they should always require interconnected decisions and actions which could be developed and adapted over time (Davids et al, 2013).

1.6 Non-linear pedagogy

The "constraints-led approach" which gives the title to this thesis, bases its principles on the concepts enunciated by non-linear pedagogy. It is therefore now necessary to explain and understand what this specific way of teaching involves.

This pedagogical model is based on the idea of ecological dynamics (Araújo et al, 2019; Davids et al, 2012) and promotes the manipulation of constraints in order to facilitate learning (Correia et al, 2018). To be more specific, Chow in 2013 identified the following core principles in the design of a nonlinear pedagogical program:

1- Representative learning design= learning must take place in situations that simulate key aspects of the performance environment, offering learners useful information to regulate their actions.
2- Relevant couplings between information and movement= the circular relationship between perception and action must support the emergence of goal-oriented behaviours.
3- Constraint manipulation= learning design must include conditions and limitations that favour the exploration, discovery and use of functional motor solutions.
4- Exploratory learning based on functional variability= activities must foster the emergence of individualised functional solutions.
5- Reduction of conscious movement control= instructions should progressively focus on the external effects of movement rather than internal aspects, thus exploiting implicit self-organization processes rather than conscious control.

As also stated in the very first paragraph, the core of this approach is the relationship between the individual and the learning environment: activities should always focus on it, as well as on the key constraints that influence performance, so that they can be manipulated in order to encourage the search for personal functional motor solutions. In practice, design becomes a

continuous and cyclical process, in which the information obtained from these individual-environment interactions become the basis for future design. The intentionality of the learner is also fundamental, as he actively seeks functional ways to solve typical performance problems, in line with the objectives defined jointly with the coach (Correia et al, 2018).

Making a comparison between traditional and non-linear approaches, the first ones are based on propositions "if-then", using progression exercises and breaking down the motor task in order to reduce the information load the learner needs to handle (Rink, 1993). However, this leads to the dissociation of the link between information and movement: breaking down a movement into isolated parts can compromise the coherence of coordinated action (Davids et al, 2006; Renshaw et al, 2010). On the other hand, a non-linear pedagogical approach adopts as a strategy the simplification of the motor task, locking or unlocking the degrees of freedom and sensory sources, in such a way as to maintain coherence between the parts of the motor pattern, allowing the effective use of information to regulate action (Renshaw et al, 2010). Furthermore, individual adaptive variability is stimulated: the search for different solutions for the same motor objective is promoted, but also the use of the same solution to solve different problems (Davids et al, 2006). This is done through the manipulation of the constraints that are imposed on the learner, with absolutely no letting a free approach to the game naturally bring out the motor solutions.

In that regard, instructions and feedback, in the context of nonlinear pedagogy, are seen as informative and non-prescriptive constraints, and therefore the aim is not to say what to do but to guide the exploration of the learner. In particular, it supports the exploration and functional use of degrees of freedom, as well as the discovery of solutions; in order to stimulate the understanding of objectives and stabilize the perception-action link (Correia et al, 2018).

1.7 Constraints-Led Approach

The "Constraints-Led Approach", also abbreviated to "CLA" is one of the pedagogical approaches that are part of the current of non-linear pedagogy. It states that "through the interaction of different constraints - task, environment, and performer– a learner will self-organise in attempts to generate effective movement solutions" (Renshaw & Chow, 2018). CLA, in full compliance with the rules of linear pedagogy, is in fact described as an approach centered on the athlete and the environmental context in which he finds himself, rather than solely on the individual. The pulsating core of this approach, as its very name tells us, is the constraints: the organization of a system is influenced by the constraints acting on it, and any change in the

constraints can lead to changes in the organization of the system. Constraints are therefore the boundaries that shape self-organization, and can be of three types:

1- Performer constraints= they are everything related to the athlete, such as his structural and functional characteristics (height and weight for example), but also his technical and tactical skills, his motivations and his emotions (Chow et al, 2007; Correia et al, 2018). Here, it is also important to emphasize the concept of "rate limits", that are those constraints that prevent the expression of acquired skills. For example, a child with limited strength will hardly be able to perform a backhand in tennis, and it will therefore be necessary to adapt instruments and spaces to cope with these temporary limitations (Davids, Button & Bennett, 2008).
2- Environmental constraints= they are constraints such as light, temperature, altitude, wind, weather; or social constraints like the presence of classmates or teachers and cultural and social expectations (Chow et al, 2007; Correia et al, 2018).
3- Task constraints= they are rules, equipment, field boundaries, number of players, objectives (Chow et al, 2007; Correia et al, 2018).

A very simple example of interaction between intention and constraints is the one that follows: climbing on a climbing wall (intention) using handholds accessible according to the length of one's arms (executor and task constraints). Coaches, the professionals of the CLA, must therefore first be able to understand what the constraints are and which ones are relevant to the task, and then learn to manipulate them with the aim of guiding the exploration and emergence of desired functional motor solutions (Renshaw et al, 2010).

Returning instead to the topic of feedback and instructions introduced in the previous chapter, they must be informative and not prescriptive. A widely used strategy in CLA is "questioning": the use of questions to guide the exploration of the athlete. Keeping the tennis example we used before, examples of questions based on the situation can be "where was your opponent when you hit the ball? What can you do differently? What happens if you hit the ball from below?" (Correia et al, 2018).

1.8 Climbing and its basic techniques

After reviewing the scientific literature concerning the pedagogical topic, it is now necessary to briefly introduce and explain climbing disciplines, as well as the basic techniques commonly used by practitioners.

Sport climbing is defined, according to FASI. (Italian Sports Climbing Federation), such as "natural climbing (which means, without the aid of artificial means used for progression) for

competitive, amateur and motor education purposes, carried out either on natural or artificial walls along itineraries controlled from the base, or on suitably equipped boulders" (Feder-climb). Three disciplines recognized by FASI and IFSC (International Federation of Sport Climbing) can therefore be distinguished:

- Lead: discipline in which practitioners, secured by a rope, climb one at a time on a fifteen meters high wall. The goal is to reach the highest possible point. The discipline is performed in pairs, so one of the two climbers climbs, while the other, from the ground, carries out the work of belaying his partner through the belaying devices and the rope.
- Bouldering: discipline that is practiced individually on a wall with a maximum height of five meter. The safety is given by drop mattresses, placed below the wall. The goal is to reach the last hold and hold it stably with two hands.
- Speed: it is practiced individually using automatic belay devices and consists in completing a route with predefined holds (which are the same for all competitions, for both male and female climbers), in the shortest possible time.

As regards technique, experts have discussed and debated for a very long time, but they have never managed to have unanimous definitions as in sports, for example, such as artistic gymnastics. The works of two authors considered "gold standard", whose technical canons were used for the evaluation of the participants, will therefore be summarized here.

The first author is Tito Pozzoli, who in his book "*Manuale di tecnica di arrampicata: Dagli schemi motori di base alle tecniche evolute*" (2020), begins to explain the technique starting from the so-called "basic positions" that we can see in the table and in the image below.

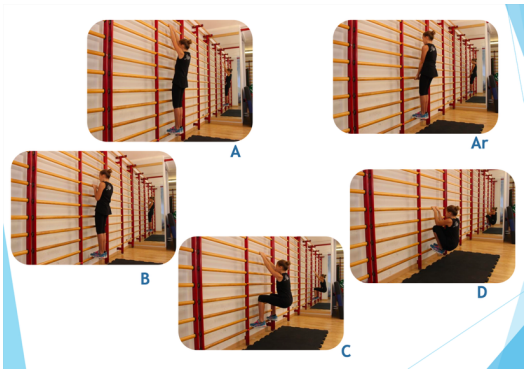
Table 1

Basic positions in climbing

Legs ↓ | Arms →	Straight	Bent
Straight	Position "A" (if straight up high) Position "Ar" (if straight down)	Position "B"
Bent	Position "C"	Position "D"

Figure 3

Representation of the basic positions



Pozzoli subsequently identifies the "basic figures", which we can see summarized in this case too in the table and image below. They are classified according to the number of points of contact with the climbing holds on the wall and whether it is a hand on a handhold or a foot on a hold.

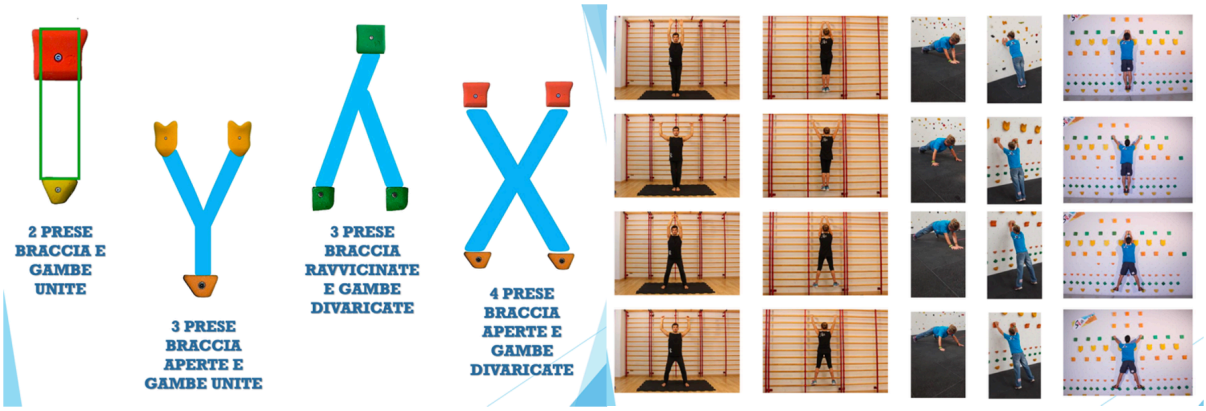
Table 2

Basic figures in climbing

Legs ↓ | Arms →	Together	Open wide
Together	Figure "I"	Figure "Y"
Open wide	Figure "λ"	Figure "X"

Figure 4

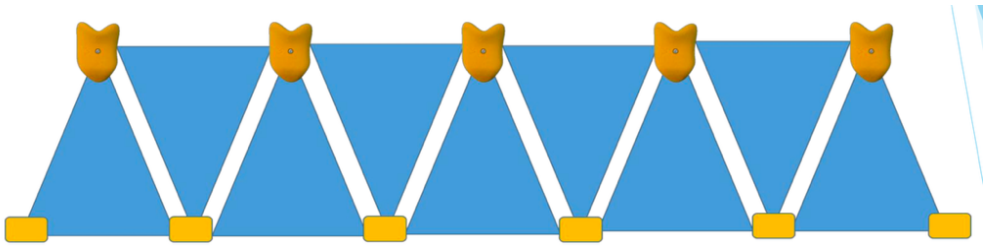
Representation of the basic figures



These positions and figures are, as we can see, just static and do not show what the real movement actually is. However, basically every climbing movement starts from these figures, so the author starts to describe the different possibilities of progression on the wall only after explaining the positions and figures. The first type of progression on the wall is called “triangle” and it is a horizontal line climb without ever climbing upwards (see image below). Triangle climbing requires that there are always and alternately two feet or two hands arranged on the same handhold-support. Having a common grip-support climbing triangle involves learning to swap feet and hands.

Figure 5

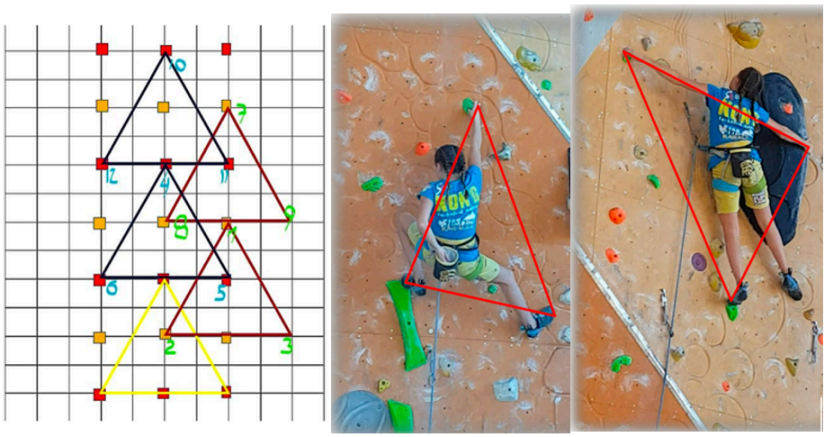
The triangle progression



Triangle climbing can then be transferred to the vertical progression, which implies going up on the wall. In the following image, we can see all the movements in order, with hands and feet shown with numbers.

Figure 6

The triangle progression on a vertical wall

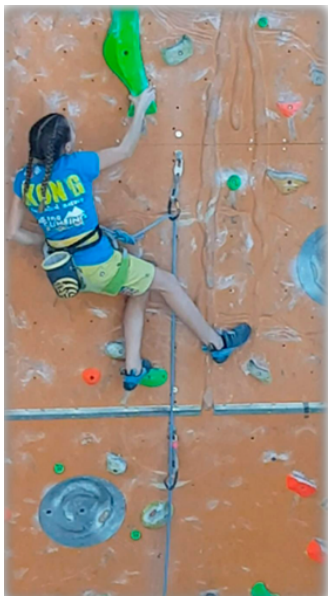


“Square climbing” is another technique, on the other hand, that involves a vertical progression with the use of the basic positions that have been introduced in the lines above, and the transition from one to the other in the following order: A→C→B→A.

The last technique that Pozzoli explains in his book (2020), is “side climbing”, a movement with opposite limbs, in which hand (handhold) and foot (support) are opposite and are on the same vertical line, maintaining body balance. In this case, a rotation of the pelvis and shoulders is executed by the climber, which allows him to reach the following hold more easily, straining the arm way less. The foot that is not resting on a hold is referred to as a “balancing” foot and aids in stabilization, balance but also in the direction of movement.

Figure 7

Side climbing



In Salomon and Vigier’s book “*Pratique de l'escalade*” (1989), three phases are instead identified in each movement on the climbing wall:

1- Preparation phase= when the climber sets his body by establishing the correct position and positioning his feet to begin the lifting action.
2- Reaching phase= when the climber stands up to reach and grab the next hold in the climbing route.
3- Stabilization phase= when the climber adjusts and relaxes the body after reaching the grip, before starting the next series of movements.

A correct climbing technique aims to make the minimum possible effort to reach the holds of a predefined climbing route. The main techniques for each phase are listed below, with the most common mistake for each of them (Beltrán Beltrán et al, 2023):

- Decoupling= energy saving technique carried out in the preparation phase which involves the arm of the support hand (i.e. the highest one that supports the weight of the body) being extended. The most common mistake is having the elbow and shoulder angles less than 150°.
- Reaching hand support= in the reaching phase, the supporting hand (the lowest one that stabilizes the body at the wall) should remain on the hold for as long as possible before reaching the next one. The most common error is the duration of the reaching movement greater than 1s.
- Weight Shift= during the reaching phase, the centre of gravity should be moved above the pushing leg, i.e. the one opposite the support hand. The knee should be brought vertically in front of the toe of this leg; the weight of the body is first moved above the leg towards the wall and then upwards. The most frequent error is the absence of this shift in the centre of gravity.
- Both Feet Set= during the reaching movement the feet should both be placed on the wall, either on a hold or pressed against the wall. If the foot moves in the air, it is considered a mistake.
- Hip Close to the Wall= The goal must be to keep the hips as close to the wall as possible. The characteristic error during the reaching phase occurs when the distance between the wall and the pelvis is greater than 5cm (climbers with similar anatomical measurements are taken into consideration).
- Shoulder Relaxing= in the last phase, the stabilization phase, after having grabbed the hold with the hand, the arm should relax again, and the centre of gravity must get low to allow this movement. The most common mistake is arm locking: the elbow and shoulder angles do not open, remaining less than 150°.

However, all these techniques refer to a very static way of climbing, in which the climber always finds himself in the situation where he has at least three limbs resting or holding on to the climbing holds or on the wall. In modern climbing, however, new movements have been developed and are being performed more frequently. Among these, there are the so-called dynamic movements, which are exactly the opposite of those we have described so far. The two most basic movements, less complex from a technical, coordination and power expression point of view, are “dead-pointing” and “dyno” (Fuss & Niegl, 2010; Long & Long, 1997):

- Dead-pointing= is a controlled dynamic movement, in which the climber approaches the wall with speed, grasping the next hold with one or two hands in the so-called “dead point”. The

movement is performed by detaching both hands from the wall, but the feet remain in contact with the holds.

- Dyno= is the movement in which all the limbs (hands and feet) detach from the wall for a certain period of time, with the aim of reaching a distant upward hold. It's essentially a leap to a hold.

The fundamental aspects to take into consideration when performing a dynamic movement are the following (Bensman, 1999; Luebben, 2014; Hill, 2007):

- Having your feet in a good pushing position.
- Keep the eyes on the landing hand hold.
- Bend your knees, start the movement by pushing with the legs and then pulling with the arms.
- Hips must move in a powerful way towards the landing hold.
- Be careful not to move your hips too far away from the wall.
- Leave your hands from the starting grip as late as possible.
- Grab the landing hold at dead point.

1.9 Thesis' purposes and hypothesis

Now that all the bibliographic sources regarding the topics of central importance have been reviewed, the true objectives of this thesis can be defined.

As can be seen from the title, the main interest of this master's thesis is to test the effectiveness of a pedagogical approach that has recently attracted a lot of attention in the eyes of researchers, in a sport like climbing. The main question therefore sought to be answered is the following: is the "Constraints-Led Approach" a pedagogical approach applicable to a sport such as climbing? Given two different groups of beginners, will teaching basic climbing techniques be more effective through the use of CLA or using a traditional, more instructive and guided pedagogical approach?

In particular, this master's thesis focuses his attention to the discipline of "bouldering", which has been increasingly popular in recent years. Thanks to its ease of access, the bouldering discipline has allowed a direct approach for beginners to climbing, without dwelling excessively on the safety standards and techniques absolutely necessary for the practice of the discipline of "lead".

Based on all the information summarized in the previous chapters, the assumptions that have been made are as follows:

- H0= no difference between the two groups.

- H1= the group that learned the techniques with CLA will perform better in a general way than the group with which a traditional approach was used.
- H2= the group that learned the techniques with CLA will perform better in bouldering but worse in technical tests than the group with which a traditional approach was used.

In the next chapter the methodology used will be explained in more depth.

2 Method

2.1 Participants

The sample selected for this study consisted of six adult participants, of which three male and three female, with an average age of 25,3 years (± 3,44). The inclusion criteria required that all participants were beginners in bouldering: some of them had never taken part in structured climbing courses and hadn't climbed more than twice in their lives; and some had climbed more than twice but took at least a one-year break from climbing before the starting of the classes.
Participants were recruited on a voluntary basis and gave informed consent to participate. Subsequently, two experimental groups of equal size were randomly assigned (simple random assignment). Group 1 was given the name "Constraint", while Group 2 was given the name "Traditional".

2.2 Context and materials

The research took place at the climbing gym "Grimper.ch - Fribourg - Le Hangar" in Fribourg, equipped with educational walls and boulder areas. The climbing walls used for teaching and assessment had different heights and degrees of inclination. The holds and the volumes were variable in shape and size, also compatible with beginner levels.
All sessions were conducted by the researcher himself, instructor and climbing coach, as well as a graduate in sport science, who held the role of instructor throughout the entire cycle of lessons. Methodological consistency between sessions was maintained to ensure the standardisation of intervention.

2.3 Procedure

Each group took part in three lessons, each focused on a fundamental technique of progression in bouldering, taken from Pozzoli (2020) and Sherman (2017):

1. Square climbing and triangle climbing
2. Side climbing
3. Dynamic movements - dead point

The lessons, which lasted about 75 minutes, took place during two weeks, in accordance with the availability of all participants.

"Traditional" group

The "Traditional" group followed a classical teaching methodology, structured as follows:

• Warm up (10 minutes)
• Theoretical explanation and technical demonstration (15 minutes)
• Guided practical exercises on educational walls (15 minutes)
• Application of the technique on boulders (30 minutes)
• Stretching (5 minutes)

Participants were allowed to choose boulders according to their level and were allowed to receive additional explanations, explicit feedback and direct support in problem solving.

"Constraints" group

The "Constraint" group followed a didactic approach based on the principles of the "Constraints-Led Approach" (Renshaw & Chow, 2018; Chow et al, 2007; Correia et al, 2018; Renshaw et al, 2010). The structure of the lessons included:

• Warm up (10 minutes)
• Presentation of an exercise-problem with specific constraints to stimulate personal solutions (20 minutes)
• Application on relevant boulders (40 minutes)
• Final stretching (5 minutes)

No explicit assistance was provided during the activities. The researcher-instructor encouraged students' autonomy by asking questions designed to raise awareness of perceived errors and encourage personal solutions.

2.4 Lessons in detail

Below you can read the two programs in detail for the respective groups.

"Traditional" group

1. Square climbing and triangle climbing= different types of jumping jacks as a warm-up → head, shoulders, elbows, wrists, hips, knees and ankles circumductions → traverse on climbing wall → theoretical explanation and demonstration of the triangle technique → repetition of the technique until it is correctly performed by everyone → trying to climb up → explanation of the rules to fall correctly → theoretical explanation and demonstration of the square technique → repetition until it is correctly performed by everyone → climbing boulders at their own level that require the use of the techniques learned (I help everyone by indicating the technique or movement to be done and, if necessary, showing what needs to be done) → final stretching.

2. Side climbing= different types of jumping jacks as a warm-up → head, shoulders, elbows, wrists, hips, knees and ankles circumductions → traverse on the climbing wall → relay race on the climbing wall → free overhang climbing → theoretical explanation and demonstration of the side climbing technique → repetition until it is done correctly by everyone → climbing on boulders at their own level that require the use of the techniques learned (I help everyone by indicating the technique or movement to be done and, if necessary, showing what needs to be done) → final stretching.
3. Dynamic movements and dead-point= jumping jacks as a warm-up → head, shoulders, elbows, wrists, hips, knees and ankles circumductions → in pairs, balancing on one leg, they try to make the other fall just by pushing hands against hands → traverse on the climbing wall → two or three easy boulders → given four starting holds, hands and feet, impose a finishing catch in such a way that it is a jump → theoretical explanation and demonstration of dynamic movements and dead-point technique → repetition until it is done correctly by everyone → climbing boulders at their own level that require the use of the learned techniques (I help everyone by indicating the technique or movement to be done and, if necessary, showing what needs to be done) → final stretching.

"Constraints" group

1. Square climbing and triangle climbing= different types of jumping jacks as a warm-up → head, shoulders, elbows, wrists, hips, knees and ankles circumductions → traverse on the climbing wall → trying to do the traverse always having three ends in contact with the wall (task constraint) → what is the best location? Let's try again and when the teacher claps the hands they need to have three limbs on the wall and with the free one touch the closest classmate, with the hands or feet (task constraint) → try to climb up → explanation of the rules to fall correctly → try to climb up freely → try to climb up trying to make as little effort with your arms as possible (performer constraint) → What should you do to make as little effort with your arms as possible? → climbing boulders at their own level that require the use of the techniques learned (I never give an answer on the technique to use or the solution, but I always ask questions about what can be done differently) → final stretching.
2. Side climbing= different types of jumping jacks as a warm-up → head, shoulders, elbows, wrists, hips, knees and ankles circumductions → traverse on the climbing wall → traverse on the climbing wall → relay race on the climbing wall → free overhang

climbing → It's difficult to overhang, isn't? Try using only three holds: big hand hold, foot hold directly underneath and far hand hold (task constraint) → How do I get to that hand and hang a band on it? (task constraint) → climbing boulders at their own level that require the use of the techniques learned (I never give an answer on the technique to use or the solution, but I always ask questions about what can be done differently) → final stretching.

3. Dynamic movements and dead-point= jumping jacks as a warm-up → head, shoulders, elbows, wrists, hips, knees and ankles circumductions → in pairs, balancing on one leg, they try to make the other fall just by pushing hands against hands → traverse on the climbing wall → two or three easy boulders → given four starting holds, hands and feet, impose a finishing catch in such a way that it is a jump (task constraint) → What needs to be done to get higher? Try to be as precise as possible (performer constraint) → Now try to jump to a right or left hold (task constraint) → What do you need to do to get further right or left? → climbing boulders at their own level that require the use of the techniques learned (I never give an answer on the technique to use or the solution, but I always ask questions about what can be done differently) → final stretching.

2.5 Measures and evaluation

At the end of the lessons cycle, participants were asked to abstain from bouldering for a whole week in order to ensure the validity of "retention and transfer tests" (Magill & Anderson, 2010). After the break, the groups took part in an evaluation session.

Participants were given twenty minutes of free warm-up time. The assessment was conducted by the researcher himself, who observed, and video-taped participants perform the four techniques learned on teaching walls (retention test) and then on four boulders designed to involve each specific technique (transfer test). The performances were then evaluated by two experts, including the researcher himself, both climbing instructors and coaches, who reviewed all the videos individually. To reduce potential observational bias, a structured and shared evaluation grid was used at the preliminary stage. The second expert was not aware of the type of group each candidate was in.

The performance was evaluated with a structured observational sheet, based on consolidated bibliographical sources:

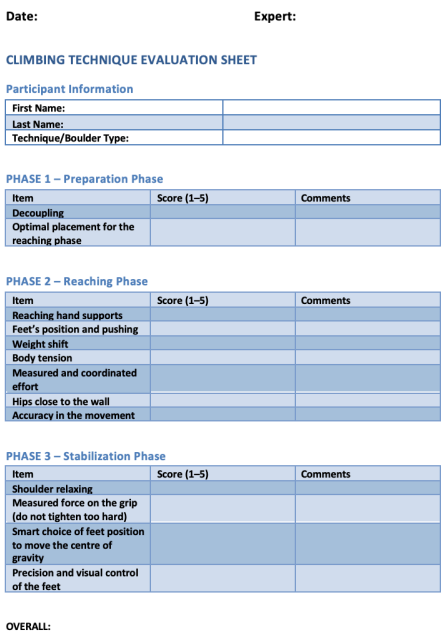
- Beal (2011)
- Beltrán Beltrán et al (2023)

- Flanagan (2013)
- Fuss & Niegl (2010)
- Long & Long (1997)
- Milani (2023)
- Pozzoli (2020)
- Salomon & Vigier (1989)
- Sherman (2017)

The evaluation sheet that the University of Fribourg uses regularly to evaluate students who take part in the exams of the climbing courses organized by the university; designed by Philippe Gay in 2015, was also used as a source.

Figure 8

Evaluation sheet



Date: **Expert:**

CLIMBING TECHNIQUE EVALUATION SHEET

Participant Information

First Name:	
Last Name:	
Technique/Boulder Type:	

PHASE 1 – Preparation Phase

Item	Score (1–5)	Comments
Decoupling		
Optimal placement for the reaching phase		

PHASE 2 – Reaching Phase

Item	Score (1–5)	Comments
Reaching hand supports		
Feet's position and pushing		
Weight shift		
Body tension		
Measured and coordinated effort		
Hips close to the wall		
Accuracy in the movement		

PHASE 3 – Stabilization Phase

Item	Score (1–5)	Comments
Shoulder relaxing		
Measured force on the grip (do not tighten too hard)		
Smart choice of feet position to move the centre of gravity		
Precision and visual control of the feet		

OVERALL:

Each technique and boulder climb were evaluated with scores from 1 to 5 on specific technical items, generating an overall score for each participant. The minimum score possible was therefore 13 and the maximum 65.

2.6 Data analysis

The statistical analysis was carried out using the software Jamovi (version 2.3.28). After verification of the assumptions of normality and homogeneity, t-tests were carried out for independent samples. The level of statistical significance has been set at $p < 0.05$.

The following variables were compared between the two groups:

- Overall average scores
- Average scores for each type of test (technique or boulders)
- Average scores for each climbing technique as part of the retention test (square climbing, triangle climbing, side climbing and dead point)
- Average scores for each boulder of the transfer test (boulders 1, 2, 3 and 4)
- Average scores for the evaluation of the two experts

3 Results

This chapter will present the results obtained through the T-tests carried out with the Jamovi software. The specific objectives of the research were related to identifying any differences in the different tests between the two groups, both at a general level and at a specific level, in the technical part (retention test) or in the bouldering part (transfer test).

The total scores (sum of the scores of all the items) of everyone for each type of test were collected in an Excel file: triangle climbing, square climbing, side climbing, dead point, boulder 1, boulder 2, boulder 3 and boulder 4. Specifically, each participant obtained two total scores for each test, one from the first expert and one from the second expert, for a total of sixteen total scores for each individual. The total number of data therefore amounts to ninety-six.

In the table below you can see an example of the Excel file used for data collection and analysis:

Table 3

Example of the Excel file used for data collection and analysis

PARTICIPANT	GROUP	TYPE OF TEST	TEST	EXPERT	SCORE
Name 1	Constraint	Technique	Triangle	1	49
Name 1	Constraint	Technique	Triangle	2	47
Name 1	Constraint	Boulder	Boulder 1	1	60
Name 1	Constraint	Boulder	Boulder 1	2	61
Name 2	Traditional	Technique	Triangle	1	53
Name 2	Traditional	Technique	Triangle	2	57
…	…	…	…	…	…

As explained in the chapter “Method”, “T-tests for independent samples” were carried out in order to highlight any differences between the two groups in a general way, for the type of test, for each test and between the evaluations between the two experts. The results obtained will now be listed.

The general average of the group “Constraint” amounts to 42.9 points, while the one of the group “Traditional” amounts to 48.9. After verifying normality and homogeneity, the t-test showed a significant difference between the two groups in favour of the group “Traditional” (*p* value= 0.001).

The average of the tests relating to the technique (retention test) of the group “Constraint” amounts to 43 points, while the one of the group “Traditional” amounts to 49.7. After verifying

normality and homogeneity, the t-test showed a significant difference in favour of the group "Traditional" (*p* value= 0.008).

The average of the tests relating to the bouldering part (transfer test) of the group "Constraint" amounts to 42.8 points, while the one of the group "Traditional" amounts to 48.2. After verifying normality and homogeneity, the t-test did not show a significant difference between the two groups (*p* value= 0.061).

T-tests were carried out for each technique and each boulder performed by the participants in the tests, but no significant differences were highlighted, except for the technique "square climbing". In this case the *p* value was less than 0.001, thus highlighting a significant difference in favour of the "Traditional" group (average= 54.8) against the "Constraint" group (average= 39.5).

Finally, a test was carried out to highlight any excessive differences in valuation between the two experts, but no significant differences were found (*p* value= 0.372).

4 Discussion

In this chapter, the results emerging from the experimental tests described in the previous chapters are analysed and interpreted. The objective is twofold: on the one hand, to verify to what extent the data collected are able to answer the research questions formulated in the "Introduction" chapter; on the other hand, to evaluate the validity of the initial hypotheses, deciding whether to confirm or reject them based on the evidence obtained.

The starting point of this thesis work was the verification of the possible applicability of the Constraints-Led Approach (CLA) in a specific teaching context: the teaching of climbing techniques related to the discipline of bouldering, practiced in an indoor environment. As illustrated in detail in the "Method" chapter, the lesson program fully respected the founding principles of CLA, integrating them coherently and systematically in the different teaching phases. The methodological approach envisaged, in accordance with the literature (Chow et al., 2007), the prevalent use of constraints referring to the performer and the task, considering the very nature of indoor climbing and the relative difficulty of modifying environmental constraints in a substantial way.

4.1 Comparison between a traditional pedagogical approach and CLA

The first level of verification concerned the effectiveness of the approach that gives the title to this thesis. The data obtained show that the group of participants who followed the CLA-based intervention, named "Constraint", achieved an overall average of 42.9 points. This value is significantly higher than the threshold of half the maximum score obtainable (32.5 points, considering a theoretical maximum of 65), indicating a significant general level of competence. This result suggests that CLA is potentially applicable and functioning even in an indoor bouldering context, at least in terms of achieving a good average performance level. However, that evidence must be interpreted in the light of direct comparison with the other approach analysed, in order to draw more solid conclusions.

The second objective of the thesis was to comparatively evaluate CLA and a traditional type of pedagogical approach, focused on teaching a technical "ideal" model to be reproduced through the decomposition of the motor gesture and the systematic repetition of its components (Rink, 1993; Chow et al, 2007). The null hypothesis (H0) formulated in the "Thesis' purposes and hypothesis" paragraph predicted the absence of significant differences between the two groups, while the alternative hypothesis (H1) assumed a superiority of the group "Constraint" in terms of overall performance.

The data collected has led to the rejection of both hypotheses. Firstly, the statistical analysis conducted by t-test for independent samples showed a *p* value of 0.001, indicating a statistically significant difference between the two groups and therefore incompatible with the null hypothesis of absence of differences. Secondly, the direction of difference contradicted the alternative hypothesis: the "Traditional" group in fact obtained an average of 48.9 points, higher than the 42.9 points of the "Constraint" group.

This result, at least apparently, seems to overturn what was expected on the basis of the scientific literature and the initial theoretical assumptions. In fact, in the Introduction chapter it has been widely discussed how modern pedagogical approaches, founded on the dynamic interaction between individual and environment (Renshaw & Chow, 2018), are considered particularly effective in disciplines such as climbing, where the variability of motor solutions and adaptation to the context constitute central elements. The rationale behind the H1 hypothesis was therefore that an approach centered on constraint and autonomous exploration of solutions would favour deeper and more transferable learning, compared to the mere repetition of pre-established technical schemes.

This discrepancy between theory and experimental results can be traced back to a number of limiting factors. First of all, the extremely small sample size (n=6, divided into two groups of three) leads to high sensitivity to individual factors. In such a narrow context, differences in previous abilities, physical or cognitive abilities and coordination among participants, can disproportionately affect the final outcome, probably masking, in this case, the effects of the intervention. Secondly, the limited duration of the training course has probably hindered the emergence of potentially CLA-related benefits. Several studies in the literature, such as the one written by Gray in 2020, are based on much longer intervention periods (for example, six weeks) and on numerically larger samples, factors that favour the observation of robust and replicable effects.

4.2 H2 analysis: effectiveness of the intervention in the specific cases of retention and transfer tests

The third hypothesis (H2) envisaged a differentiation of the effectiveness of the two approaches in relation to the type of test: in particular, it was hypothesized that the group "Constraint" would perform better in bouldering tests (transfer tests), while the group "Traditional" would have obtained superior results in the tests related to climbing technique (retention tests).

The results partly confirmed this hypothesis, but only with regard to the second part, i.e. the superiority of the traditional group in retention tests. In this type of test, aimed at evaluating the

executive quality of technical gestures already learned, the group “Traditional” achieved an average of 49.7 points, significantly higher than the 43 points of the group “Constraint”. The difference, in addition to being consistent from a numerical point of view, was statistically significant (p value = 0.008). This outcome is consistent with the theoretical rationale: the repeated repetition of movement, typical of the traditional approach (Rink, 1993), favours the stabilization of specific motor patterns, improving the technical execution in contexts similar to those of learning.

The situation was different for the transfer test, in which the ability to deal with new bouldering problems was evaluated, requiring adaptation to situations not identical to those exercised during training. The hypothesis predicted a superiority of CLA, by virtue of the increased time spent practicing bouldering under variable conditions and the emphasis placed on autonomous exploration of solutions (Chow, 2013; Correia et al, 2018; Davids et al, 2006). However, the data again showed an advantage of the “Traditional” group (average = 48.2 points) over the “Constraint” group (average = 42.8 points). In this case, the difference, although numerically appreciable, did not reach statistical significance (p value = 0.061), suggesting that it could be an insufficiently consolidated trend.

To conclude the discussion of the statistical analysis of the data obtained, a t-test was also carried out to evaluate any excessive differences in evaluation between the two experts. The test showed that the assessments of the two experts were sufficiently coherent and in fact the p value amounts to 0.372, thus demonstrating great reliability of the data from an evaluation point of view.

4.3 Possible explanations and methodological limitations

The failure to find the initial hypotheses and, in particular, the absence of advantages of CLA even in the transfer tests, requires a critical reflection on the factors that may have influenced the results.

Firstly, as already mentioned, the small size of the sample represents a substantial limit. With only three subjects per group, the impact of individual differences —for example in terms of previous climbing experience, physical strength, coordination skills or even motivation — can be decisive, reducing the possibility of generalizing the results.

Secondly, the overall duration of the intervention may have been insufficient to allow the CLA to fully express its potential. Approaches based on exploration and guided discovery often take longer to translate into observable improvements, in that learning develops gradually and needs

progressive consolidation through varied experiences. The use of a traditional pedagogical approach, which means having many instructions and many direct inputs from the teacher, when you are just starting out, on the contrary significantly accelerates the learning process, especially in the short term.

A third element to consider concerns the so-called “novelty effect” which may have influenced the participants of the "Constraint" group. In fact, the participants of the "Traditional" group may have benefited from the fact that the teaching methods were more similar to those already known in other sports or school contexts, reducing the initial learning curve. In contrast, the CLA group was faced with a less familiar methodology, which requires first of all greater cognitive investment and a longer initial adaptation phase.

4.4 Implications for practice and future prospects

Although the results obtained have not fully confirmed the hypotheses formulated, they provide useful indications both for future research and for the practice of teaching climbing techniques. First of all, having demonstrated the overall good performance of both groups, it can be confirmed that both CLA and the traditional approach can lead to significant improvements in climbing skills in an indoor bouldering setting. The choice of approach could therefore depend, at least in part, on the specific aims of the intervention: if the objective is the refinement of well-defined technical gestures, the traditional approach could be more immediately effective; if, on the other hand, the aim is to develop motor adaptability and problem solving, CLA could express its strengths in more variable contexts and with longer application times.

Secondly, it is very clear that the results underline the importance of having numerous samples and adequate intervention periods to correctly evaluate the effectiveness of complex pedagogical approaches, which are already very difficult to evaluate. Future studies should therefore aim to involve more participants, balancing groups by initial level and physical characteristics as much as possible and extend the duration of the program to allow CLA to produce its medium-long term effects.

Another factor that would be interesting to evaluate is the effectiveness of CLA and a traditional pedagogical approach applied to different age groups. This research was limited exclusively to a limited group of young adults, but the effects could prove totally different if the same methodologies were applied to groups of children, adolescents or adults over 30. For the same reasons, it would be very interesting to see the pedagogical principles of the CLA applied on a group of athletes instead of on a group of beginners as it was done in this case. We could then

look for and highlight the differences even with learning groups of different levels, intermediate or advanced for example.

Finally, a final aspect that future research could consider in order to evaluate the "Constraints-Led Approach" from all points of view is the psychological one. The perception of learning, as well as of the teaching methodology, by a learner could totally change the latter's experience. The use of a pedagogical approach that is pleasant in the eyes of the individual could significantly influence his motivation and consequently also his performance. It could therefore prove extremely interesting to submit questionnaires regarding the perception of lessons, personal satisfaction and motivation, with the aim of carrying out a qualitative analysis of this aspect.

5 Conclusion

In conclusion, this master's thesis wanted to address and analyse the topic of non-linear pedagogical approaches, with a main focus on the “Constraints-Led Approach”. All the theoretical bases necessary to fully understand the topic were provided, starting from the learning of a motor skill up to the principles and the specific and practical use of a pedagogical approach. In particular, sport climbing was used as a mean to evaluate the actual use and effectiveness of CLA, creating a teaching program for beginners and evaluating its results in terms of performance compared with a traditional pedagogical approach.

Two questions were asked at the beginning: is it possible to apply CLA to a program of teaching climbing techniques? Will teaching via CLA be more effective than traditional teaching?

Thanks to the bibliographic review performed in the beginning, the creation of the two distinct teaching programs and the tests carried out at the end of the intervention, this thesis has shown that it is possible to successfully use the “Constraints-Led Approach” to teach the basic climbing techniques to a group of beginners. However, CLA, used in a very short-duration intervention and on a limited sample of three participants, has not proven more effective than a traditional pedagogical approach.

Despite this, the work carried out by this thesis, has managed to lay the theoretical and practical foundations for future developments. This thesis wants to set itself as a starting point for further studies and analysis of practical interventions using this pedagogical approach, both in climbing and in different sports contexts. In particular, it would be useful in terms of research to cope with the limitations of this work, such as the small sample and the short duration of the intervention.

Future insights could first concern the application of CLA in multiple sports with very different characteristics. It would also be interesting to evaluate the “Constraints-Led Approach” with different categories of individuals: adults, adolescents, children and make a distinction based on the level, be they beginners, intermediates or athletes. Finally, in this context the perception of the pedagogical approach from the psychological point of view, that is, how it is perceived and possibly appreciated by learners, has not been evaluated; a theme that would be of crucial importance to evaluate its use and effectiveness in general terms.

In conclusion, the last hope of this thesis is that it will be the bearer of an example of conscious teaching, based on scientific data and modern knowledge, showing that scientific developments in terms of performance must go hand in hand with those relating to learning and teaching, not letting the latter stagnate in ancient knowledge and applications that are not changed over time.

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Annexes

Gay, P. (2015). *Rapport "Tectac"*. University of Fribourg

Rapport « Tectac »

Rapport technique et tactique Sur la base du Mouvement Standard	Nom Date	Voie Qualité / Difficulté		
Domaine mental	**Appréciations**	**+**	**+/-**	**-**
• Motivation, concentration				
• Décision pour la prise suivante				
• Anticipation du mouvement				
Domaine Physique				
1. **phase de préparation** **Bien se placer pour saisir de la prochaine prise de main en bougeant les pieds et le CG***				
• Reprendre la prise lâchée en phase finale				
• Garder les bras tendus (si la voie est raide)				
• Choix des prises de pied judicieux pour déplacer le CG*				
• Précision et contrôle visuel des pieds lors du déplacement du CG*				
• Placement optimal pour la phase principale				
2. **Phase principale** **Pousser sur les pieds, tirer sur les bras, bloquer, pour attraper la prochaine prise de main**				
• Traction : Deux mains sur les prises pour monter le CG*				
Pousser sur les pieds				
Tension corporelle				
Doser et coordonner l'effort				
• Saisie de la prise : Lâcher la main de soutien au dernier moment				
Précision dans la saisie				
3. **Phase finale** **Stabiliser, chercher une position de minimum d'énergie (PME) sous la nouvelle prise**				
• Doser l'effort sur la prise saisie (ne pas la serrer trop fort)				
• Garder les bras tendus (si la voie est raide)				
• Choix des prises de pied judicieux pour déplacer le CG*				
• Précision et contrôle visuel des pieds lors du déplacement du CG*				
• Chercher un relâchement conscient, expirer				
• Décontracter le bras qui a bloqué la traction, dégainer				
Observations générales				
• Maniement de corde				
• Lecture et compréhension générale de la voie				
• Rythme, vitesse				
• Souplesse, amplitude				
• Gestion de l'imprévu et créativité				
• Gestion des émotions (stress, peur)				
• Détermination, combativité				

***CG : centre de gravité**
PME : position de minimum d'énergie

Ph. Gay (2015)

Déclaration de consentement

UNI FR
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UNIVERSITÄT FREIBURG

SCIENCES DU MOUVEMENT ET DU SPORT
BEWEGUNGS- UND SPORTWISSENSCHAFTEN

Déclaration de consentement pour la participation à l'étude

A constraints-led approach to teaching climbing techniques

- Lisez attentivement le formulaire ci-dessous.

- En cas d'incompréhension ou besoin de précisions, demandez des informations supplémentaires

Le/la signataire confirme :

- Je garantis qu'aucun des critères d'exclusion suivants ne me concerne :
  - *Perturbations neurologiques ou motrices*
  - *Maladies ou blessures cérébrale et/ou cardiovasculaires graves*
  - *Grossesse*
  - *Epilepsie*
  - *Pacemaker*
  - *Implants auditifs*
  - *Métal dans le corps*
- Je sais que je peux interrompre l'étude à chaque instant sans conséquences négatives, même si j'ai signé cette déclaration de consentement.
- Je comprends que toute donnée personnelle, les résultats des tests ainsi que la participation à l'étude sont traités confidentiellement et anonymement, et ne sont disponibles qu'aux chercheurs directement impliqués dans l'étude.
- J'accepte que les données récoltées soient publiées de manière anonyme et dans une forme non-identifiable dans une ou plusieurs publications scientifiques.
- Je consens à être filmé pour des fins d'étude.
- Je me propose volontairement en tant que participant à l'étude nommée ci-dessus.
- Les éventuelles questions ont pu être posées et ont reçu une réponse claire.
- J'ai lu et compris les informations relatives à l'étude et accepte les conditions.

Participant/e

Prénom et Nom : _____ Signature : _____

Personne ayant expliqué les informations relatives à l'étude

Je confirme avoir expliqué au participant nommé ci-dessus le genre, le but, la durée ainsi que les effets et les risques de cette étude.

Nom et prénom : _____ Signature : _____

1 09.06.2025