Freezing

Bernstein's Degrees of Freedom Problem in Fly Casting Instruction

Fly fishing can definitely be a challenge. Anglers must maintain control of the loop and their fly over increases in distance, changes of plane or trajectory in a wide range of changing environmental conditions.

To learn to do this, a caster must be able to connect the outcomes they observe to their movements as they cast and learn how to adapt how they move to meet the demands of the environment in which they do it. It is a process of continuous review. In a lesson, this cycle of reviewing movement and outcome requires a caster to think.

Our working memory is the mental space we use for processing incoming data and unfortunately, it has a finite capacity.[1] Thinking places a cognitive load [2] on this part of a casters brain. As instructors we have influence over both the size of the cognitive load that our student experiences and the rate at which it is applied. We have two ways to do this.

1. Optimise the "Intrinsic" cognitive load. This is the mental effort required to perform and process the movement on its own. This is determined by how complicated the movement is and the skill level of the caster.

2. Minimise the "Extrinsic" cognitive load. This is the mental effort required to process information, instructions and feedback about the movement that may or may not be relevant to its execution.

As we improve, our ability to review results and adjust movement to achieve our objectives speeds up, becomes increasingly automatic and the cognitive load goes down.

At the very beginning however, when we first attempt to learn a new movement pattern, the cognitive load is very high and this triggers a motor-learning challenge that every beginner and every instructor must address. This challenge was described by the Russian neurophysiologist Nikolai Bernstein as "The Degrees of Freedom Problem" [3].

Bernstein studied how humans learn coordinated movement. He observed that the human body has a large number of joints and muscles. Each joint or limb could move in many ways and these he described as degrees of freedom. These, in combination, could produce an enormous number of possible movement patterns. When learning a motor skill, the brain must somehow control all these variables to produce stable, effective actions that work to meet any given environmental objective within our cognitive limits.

Bernstein framed the learning process in three broad stages:

1. Freezing degrees of freedom – simplifying movement by limiting joint and muscle involvement.
2. Releasing degrees of freedom – gradually allowing more joints and muscles to contribute.
3. Exploiting degrees of freedom – using the full system efficiently, adaptively, and creatively.

This framework maps remarkably well onto the progression we see in fly casting skill acquisition.

Freezing Degrees of Freedom.

"The initial problem facing the learner is what to do with all of the possible degrees of freedom that are available for the body" [4]

In early casting instruction, students commonly exhibit stiff, disjointed, physiologically constrained movements. Perhaps the most common example is when the elbow movement is restricted, or the shoulder, leaving the wrist as the single joint free to move and the rest of the body largely unmoving. We most commonly refer to the resulting phenomenon as wristing, an almost wrist only cast. If it is the shoulder that is free to move we see long arm reaching, extending upwards or outwards, especially when the caster is trying for distance. If it is the elbow, the wrist is commonly locked solid and the forearm is the only limb in motion, frequently tucked in to the side or hips and the knuckles showing obvious signs of overgrip.

From a traditional coaching point of view, this looks like poor technique, which of course, it is. However, viewed from Bernstein's perspective, it is a necessary, and completely normal, learning strategy. By "freezing" degrees of freedom, learners automatically reduce complexity in the process of developing any underpinning movement patterns. Thus, they reduce the intrinsic cognitive load.

Traditionally, within a "see fault, fix fault" lesson framework, instructors look to correct this behaviour with direct instruction on how to more effectively manage these joints and limbs. This is intuitively the way to tackle the problem. A study of Bernstein however, would indicate that to be genuinely effective, instructors should simply acknowledge this stage as part of the developmental process and avoid overwhelming students with excessive cues or instructions on how to "fix" the problems caused by these locked up joints. This is because this kind of intervention is adding to the extrinsic cognitive load not minimising it. It might look grim and cause all sorts of horrible discontinuities but, at this point, if we accept that the freeze will eventually thaw naturally, we can, and should, work with it rather than against it.

Freezing is not a problem, it is a completely normal cognitive behaviour that we all experience as we develop new movements. An attempt to fix it, runs the risk of simply

moving the problem from one joint to another. You can stop it happening “there” but it will pop up again over “there”. Patience is the key here.

Releasing Degrees of Freedom

As learners begin to gain basic control, they begin to “release” degrees of freedom in an effort to find more effective movement. It is usually as obvious to them as it is to us as observers that freezing is not delivering optimal outcomes and so they experiment by adding motion with other joints and limbs and testing against the objective. The wrist starts to function more normally, subtle forearm and shoulder rotation appears, the torso may begin to contribute and these additions allow for more co-ordinated motion and improving loop control.

Bernstein’s framework reminds instructors that early self enforced physiological constraints are just temporary cognitive scaffolding, not permanent technique.

Good fly fishing instruction at this stage focuses on developing adaptability rather than rigid replication of positions or patterns. Practice drills should include variation in task complexity to help the nervous system integrate new degrees of freedom without losing control. This may be as simple as alternating between wide and narrow loops or changing trajectory whilst false casting.

This is a period where prior instructions designed to “fix” or correct the problem can begin to cause trouble. Students who were directed to reduce wrist motion, or lock it up completely, may stick to that rule, even when it limits progress. This is particularly true in the early stages of learning when casters are looking for loose rules as guidance for pattern execution.[5] When intermediate casters come for instruction it is often because the “rules” they were given in early learning have delivered stable patterns but have become so ingrained that they struggle to vary what they do when conditions or task demands change.

Exploiting Degrees of Freedom

Expert fly fishers fully exploit their degrees of freedom. Their movements are relaxed, efficient, and highly adaptable to changing conditions. Wrist, arm, shoulder, torso, legs work together in synergy[6].

At this stage, movement often looks effortless. This is because the caster is doing less thinking, the process is self-organizing. Variability becomes a feature of skill execution rather than a flaw, and fine adjustments happen in real time.

Implications for casting instruction

Bernstein’s degrees of freedom problem explains why beginners look stiff, why intermediate casters sometimes struggle to adapt, and why experts appear effortless.

It encourages instructors to accept a wide bandwidth of error in the early learning phases and favours teaching using broad developmental processes rather than error reduction and idealised invariant patterns or techniques.

The kind of body tension we regularly observe simply signals an early learning stage, it indicates a learner managing complexity, not failing. Learners need to be guided through this stage. This doesn't mean correction it means designing practice routines and drills that encourage progression by adding incremental difficulty or variability. Or it may mean giving a caster confidence simply by explaining that freezing is normal and a necessary part of the process.

Bernstein emphasized that true skill is not repetition of a single "perfect" movement, but the ability to achieve consistent outcomes under changing conditions. This insight aligns perfectly with fly fishing, where no two casts are ever exactly the same. So, instruction should not rely on replicating a fixed, idealised technique.

Fly casting is about learning to organize a complex system in pursuit of a simple goal, placing a fly where it needs to be. Variability is essential for long term development. Learning requires exploration, not just repetition. By aligning instruction with how humans naturally learn to move, instructors can reduce frustration, accelerate skill acquisition, and produce more adaptable, confident anglers.

---

[1] **Miller, G. A. (1956)**.
"The magical number seven, plus or minus two: Some limits on our capacity for processing information". Psychological Review, 63(2), 81–97.

[2] **Sweller, J. (1988).**
Cognitive load during problem solving: Effects on learning.
Cognitive Science, 12(2), 257–285.

[3] **Bernstein, N. A. (1967).**
The Coordination and Regulation of Movements.

[4] **Schmidt and Lee (1991)**
Motor Learning and Performance

[5] **Fitts and Posner (1967)**
Human performance

[6] **Turvey, M. T. (1990).**
Coordination.
American Psychologist, 45(8), 938–953.