The Modelling in the Sport for Physics's Learning: Fosbury-Flop and Judo's Cases

Francesca Bradamante, Marisa Michelini, Alberto Stefanel
Unità di ricerca in didattica della fisica dell'Università di Udine, Italia
francesca.bradamante@fisica.uniud.it; michelini@fisica.uniud.it; stefanel@fisica.uniud.it

Abstract

Starting from situations of common experience and real contexts, we carry out quantitative analysis of process and formalization with the support of information and communication's technologies.

Sport is one of the most fruitful contexts, even if is not the most simple to analyze: it motivates students because it is part of their real life. High jump and fosbury-flop method is an interesting example where we can propose a quantitative analysis of motion. Computer modeling in open environment is used for this scope. The first level is the description of the translational component of jumper following the center of mass motion , and the second one allow to represent the mechanics of rotations, that use the angular moment's conservation for clearance of the bar.

Judo allow to discuss how can be optimized system's interactions, transforming collision's situations on transfer's conditions of momentum and energy.

1 Introduction

The literature pointed out the students' difficulties in the conceptual change from sensorial and commonsense ideas to scientific conceptions, due to the lack of connection between everyday experience and physics models [1].

How to overcome conceptual knots in mechanics is very studied, because its central role in physics. The strategy is based on involving pupils in order to compare hypothesis and experimental data of phenomena [2-5].

One of the most important goals is to educate to formulate rigorous and consistent hypothesis, because it implies the typical processes of variables selection and building a formal model [6,7].

Students have to understand that physics models have the role of analogical formal descriptors of world's selected aspects and not of idealized and approximate representation of phenomena or of complex systems, like into traditional teaching vision [6].

Moreover, understanding models' potentialities and limits we are able to select aspects for everyday phenomena interpretation that frequently appear to be complex.

Illustrative teaching of principal models cannot form to build physical models: we must educate to manage formal thinking process [8] by teaching physics from specific contexts.

There are many field in which physics is an interpretative instrument and is applied [9]: curricular research can and must construct teaching proposals, starting from situations' analysis in specific contexts in order to learn how physics interprets phenomenology. Thus stimulates interest and motivates an active learning.

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Our purpose is to give a contribution in the construction of learning proposals, that improve an active strategy in exploring and analyzing the motion, in building physics modeling in two different sport's contexts: high jump and judo. Educational open environments [10-14], already available for data acquisition and computer modeling exploration, are the reference tools of our proposal [3,4,6,15,16].

2 The case of the Fosbury-flop in the high jump

The fosbury-flop method, now used in the high jump is an interesting example of complex motion that we can analyze with gradually more articulated models.

The jumper's motion can be divided into three parts: run-up, take-off and bar clearance [17]. During the take-off and bar clearance the system motion is a combination of translational motions, and rotations around longitudinal and transverse axis, that can be analyzed separately [17-20].

The simpler description of high jump is the analysis of jumper's center of mass motion, using a free body model: we proposed it as a first step in learning modeling process. It gives information about the total body motion and moreover it's essential when we consider the body description decomposed in rigid elementary parts.

In literature we find techniques to determine jumper's center of mass: static methods are interesting [21], like dynamic ones [22].

Center of mass trajectory, respect to a fixed frame of reference, is a continuous curve: in the run-up phase it can be considered as a horizontal segment (that coincide with the displacement from starting point to take-off one), and it's joined smoothly with a parable that describes bar clearance [17].

High jumper achieves the continuous connection between the trajectory of first and second phase by a complex movement in the take-off: he flexes legs (for the upward vertical thrust of the take-off) and rotates the trunk, while the center of mass maintains a positive (upward) vertical motion.

To explain that, we implement a simple analogical model [12], [17], where high jumper is represented by a massless rigid rod and a coaxial cylindrical mass (the same of jumper's), linked to the rod by a spring and shifting its position along the rod. The rod rotates in the vertical plane around take-off point, while cylindrical mass shift along the rot (describing haunches' lowering in the last but one step): the right choice of spring elastic constant allow the system to do the observed trajectory, where, instead of legs flexion, there isn't a lowering of center of mass.

Force platform of piezoelectric quartz measures the upward vertical motion in the take off: the jumper exerts a force ten times stronger than his weight [23]. With simple jumping toys [24] or a bouncing ball [25] we can recognize that the take-off fase is just a collision of the foot with the platform.

Biomechanics studies consider jumper body to be divided into different rigid parts connected with knuckle joints (legs, trunk and head, with rigid or mobile connections, up to 14 segments).

Also mechanics modeling systems for teaching describe parabolic motion of center of mass system, showing for example that the center of mass can pass below the bar. Moreover in the motion of different body parts total angular momentum respect to the center of mass is conserved.

3 Seoi-nage and okuri-ashi-barai cases in judo

In judo action the two athletes (T-Tori: who make the projection, U-Uke: who is projected) are always interacting with each-others. In a frequent judo technique like seoi-nage we recognize three phases: lack of balance (the center of mass of U is shifted from the plane of feet support), loading (the composition of two rotations around axis, with approximately the same center of mass, give a rotational motion to body U), projection (U is still rotating, and his center of mass lowers until ground impact) [26].

By film analysis, like suggested in literature [27], we analyze the judo technique in a non-competitive context.
Studying motion of body U's single points [28] in films for training improvement [13] we can recognize the spiral trajectories: body U has a rotational movement with angular velocity generally increasing linearly.
This motion has been simulated by giving to the rigid body a couple of forces that determine a constant momentum.

Similar method has been used to analyze another judo action (okuri-ashi-barai) in order to explain the role of couples of forces that T exercises for determine the rotation of U. In this case another relevant aspect is resonance. In particular this aspect can be proved with an IP simulation of movement of U's legs, consisting of two coupled pendulum.

4 Conclusions.

Since many years biomechanics is interested to high level sport, and usually considers human body to be divided in 14 segments; the dynamics of each segments is described starting from kinematics data of films in order to improve performances. Its purpose is to represent each part of human body in order to value all muscular forces by applying mechanics.

Physics do the inverse process in modeling: it selects some aspects for finding a more general interpretation and models coherent with theory and that biomechanics use to find adequate parameters.

This is one example that explains connections and differences between science and technology.

Our educational proposal is based on the construction of gradually more complex models in order to analyze the observed motion in the frame of mechanics theory. We propose different way of phenomenology interpretation to compare the physics and technological way of thinking: biomechanics' modeling stimulates us to explain physics role in this process.

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