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ANIMATE THE FORMAL TOOLS IN ORDER TO RECONCILE THE LOCAL OBSERVATIONS TO THE STUDY OF MOTION IN PHYSIC

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Abstract
Objectualization of abstract entities is often needed to create a bridge to move from observation to interpretation of the phenomena. Starting from the objectualization of the concept of vector, its components and the principle of composition and decomposition of the motion, has developed a methodology that, through Flash animations, allows learners to address the conceptual knots produced by the common sense knowledge. Motion are reconstructing step-by-step by the pupils so they can focus their attention on the physic principle, not on their mathematic formalizations. Animation so laying between the modeling and the graphical representation of formal tools and so allows to build a bridge between the observations of local common sense and the global physics view.

1. Introduction
The research literature in physics education has shown that in some cases, traditional approaches do not allow students to address the conceptual knots produced by common sense knowledge that disagree with the scientific description of a specific phenomenology (McDermott et al, 1987; Van Heuvelen, 1991; Titus, 1998). Strategies focused on students' manual and intellectual operativity (Viennot & Raison, 1999; Vosniadou, 2001) and which encourage the active involvement of the student (Michelini, 2005; McDermott, 2004) have proved to be able to activate reasoning of conceptual re-elaboration.
Creation of multimedia tools more user-friendly and portable on different platforms has token an increasingly important role in supporting teaching. The different strategies in which multimedia tools are used in classroom, integrating with the various school activities in a flexible way, promote some main educational goals such as the articulation of reasoning and the development of formal thinking and logical skills. (Michelini et al, 2006).
Identify some basic rules and assess their consequences in a computational experiment in which are re-applied the same rules can allows students to focus their attention on physical model, conceptual meaning and problems of its interpretation.
Animations are the most elementary framework in which students can test a model and can explore its outcome and also they serve as an aid in the visualization of abstract concepts by creating a bridge between reality and the mental model that students built spontaneously in interpreting the phenomena (Duit & Treagust, 1995, Gilbert & Boulter, 1998).
Animation, as objectualizator of abstract entities, becomes a bridge needed to move from the observation of phenomena to their interpretation and promote the beginning of the process of conceptual change starting from common sense to scientific formalization (Pfund & Duit, 1993; Vosniadou, 2008).
System of reference and composition and decomposition of the motions are the mainstay that all the kinematics uses. Unfortunately, often them remain implicit and the focus is often put on the motion description or to the relations that characterize it, producing so the known difficulties of the students in this field (McDermott et al, 1987).

2. Metodology
Starting with the introduction of simple elements (such as vectors) three multimedia flash animation, aimed to explore step by step the results of the repeated application of the principle of composition of motions, are illustrated. At primary school level was tested an educational path that has led to approach the study of motion in a two-dimensional space learning to build the components of the motion on the floor (Brussolo & Michelini, 2006). In two dimensions the system of reference cannot be omitted and, with it, the composition and decomposition of the motion. The proposed conceptual strategy uses the symbolic vector representation to create the bridge between the phenomenon and its first graphic representation in physics space and in the position-time plot, building and distinguishing it from the trajectory.

Symbolic transduction in to the virtual world of computer was done in three specific cases: 1) the uniform circular motion as the result of shifts produced by a constant vector, which changes the direction of the same angle at each step of motion (constant time interval), 2) the parabolic motion, made step by step using an iterative process in which a constant acceleration acting on the vertical downward velocity vector, at each step the components of displacement on the two orthogonal axes of the reference system constructed of two shifts, respectively, uniform and uniformly accelerated motion in the horizontal and vertical, 3) the Archimedean spiral motion, due to the Coriolis acceleration, constructed step by step from the composition of a uniform rectilinear motion and a circular uniform one.
Flash animations at this stage become only an operating facilitator leaving to the user the conceptual dimension. The iterative analysis of the rules used in each case offers a new interpretation of the motions in terms of composition of motion through the relative displacement (i.e. speed in constant range of time). This form of modeling, based on the objectualization of the virtual velocity vector and its components, also allows to analyze motions which formal treatment is particularly complicated, as in the case of Coriolis motion.

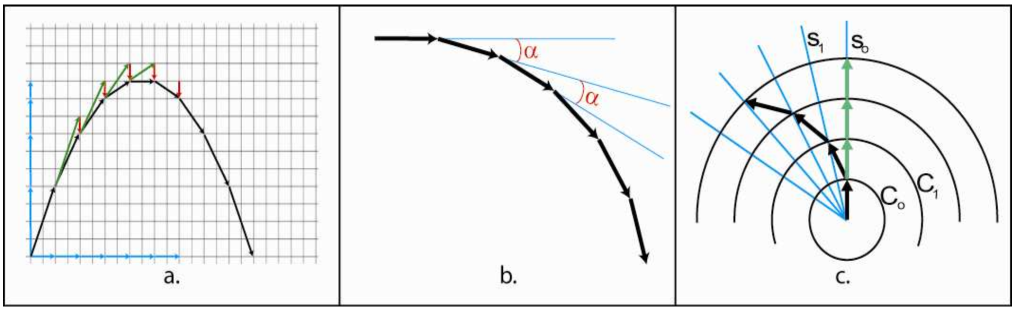

Figure 1: Type of Motions

Uniform circular motion falls within the daily experiences of students. Its features are simple from a conceptual standpoint, but its most simple description involves formal analysis in a polar reference system, which considers the centripetal acceleration component to produce speed changes. The animation suggests the opposite path. The length of the velocity vector does not change over time, while its direction depends on the uniform change of an angle at each time interval throughout the motion. The animation so graphically display how the composition of these two elements gives rise to a uniform circular motion. It starts representing the initial vector of motion and then what followed in the case of uniform rectilinear motion (identical to the previous one with same direction). On this second vector is applied a rotation obtaining a displacement vector of the same length of the previous rotated, as represented in the drawing (Fig. 1b). In this way the student understands how a simple definition based on the characteristics of motion can regain motion rebuilding it step by step from its foundations.
Parabolic motion is the result of a composition between an uniform motion in a horizontal direction and an uniformly accelerated motion in a vertical direction. One approach that brings out this feature from the construction of the motion step by step helps to consolidate the properties and give the reference system the crucial role he has. The invariance of the horizontal component of speed (and hence the movement in units of equal time) allows to show that the motion along that direction is straight-type uniform. In contrast, the variation on the vertical component of speed (and the consequent displacement) indicate the presence of a uniformly accelerated motion. The nature of the parabolic motion as a composition of two simple motions is illustrated from the soul that apply in detail the schematic of the proposed rule iterative (Fig. 1a).
The Archimedean spiral motion is the composition of two simple motions: a uniform rectilinear and uniform circular one. The discussion is greatly simplified by building the motion step by step and using the objectualization in an analysis of the concept of vector graphics. To do this you draw the initial displacement vector s_0 of uniform motion speed and a circumference C_0 centered on the point of application of the vector s_0 and radius equal to the length of s_0. It also draws the direction of s_0 which represents the direction of uniform motion. It traces the circumference C_1 concentric to C_0 and having radius $2s_0$. The ray s_1, which forms an angle α equal to the angular displacement of the rotating system in the time interval that occurred to produce the displacement s_0, intercept C_1 in

the end of the second displacement vector. Repeating the process on the new vector will get a spiral trajectory (Fig.1c)

3. Conclusions

Traditional teaching methods don't allows students to overcome the conceptual knots that are at the basis of the vector representation of the motion. This leads to having to bring work in scalar terms, i.e. taking into account one-dimensional motion in which the role of the principle of composition of motion remains implicit. Starting from objectualization of the concept of vector, are proposed an iterative way to build plans motions, which play a conceptual animation of formal tools. The construction for subsequent time intervals equal to the vectors of motion becomes an instrument characterization and interpretation in the decomposition of the motion in a reference plane. The role that takes the animation in this way the white building as a means of formal thought and especially between the local observations of common sense and to global physics, placing them in an intermediate space between the modeling and graphical representation of formal tools . To account for the feasibility of this proposal has been presented here is the introduction of the preliminary conceptual route description dimensional vector space and travel on it in motion plans, both the manner in which it is proposed as the animation oggettualizzazione virtual vector description of motion plans focusing on the role of the reference system, the meaning of trajectory than that of plot time and composition of the movements as the operational definition of the motions themselves. The promising conceptual meanings have so far been explored only in pilot experiments, aimed at developing the proposal; there are plans to extend them to other movements and introduced in pilot testing of basic physics at secondary level.

References

Brussolo & Michelini (2006) Una proposta per lo studio del moto nella scuola primaria, tesi di laurea facoltà di Scienze della Formazione Primaria, A.A. 2006-2007.

Duit & Treagust (1995) Improving Science Education, 1995, 174.

Gilbert J.K. & Boulter (1998) Learning Science through Models and Modelling, in B.J. Fraser and K. G. Tobin (eds), International Handbook of Science Education, The Netherlands: Kluwer, 1998, 53-56.

McDermott (2004) Physics education research: The key to student learning and teacher preparation, in Proceedings of the 2nd International GIREP Seminar on Quality Development in Teacher Education and Training, University of Udine, Italy, September 2003, edited by Marisa Michelini, University of Udine, 30-34 (2004)

McDermott et al (1987) Rosenquist Mark L., van Zee, Emily H, Student difficulties in connecting graphs and physics: Examples from kinematics, American Journal of Physics, Volume 55, Issue 6, pp. 503-513, 1987.

Michelini (2005) The Learning Challenge: A Bridge between Everyday Experience and Scientific Knoledge, GIREP book of selected contributions, Ljubljana, 2005.

Michelini et al (2006) Santi L., Stefanel A., Esperimenti e modelli in ottica fisica per l'innovazione didattica e la formazione degli insegnanti, in Incontri di discipline per la didattica, Griggio C ed., Franco Angeli, Milano (Italy) p. 365-392, 2006.

Pfundt & Duit (1993) Students' Alternative Frameworks and Science Education, IPN Kiel, Germany 1993.

Titus (1998) Integrating video and animation with physics problem solving exercise on the World Wilde Web. PhD dissertation North Carolina State University, 1998.

Van Heuvelen (1991) Learning to thing like a physicist: A review of research-based instructional strategies, Am. J. Phys. 59, 1991, 891-897.

Viennot & Raison (1999) Design and evaluation of a research-based teaching sequence: The superposition of electric field, International Journal of Science Education, 21, 1, 1999, 1-16.

Vosniadou (2001) How Children Learn, Educational Practices Series, 7, The International Academy of Education (IAE) and the International Bureau of Education (UNESCO), 2001.

Vosniadou (2008) International Handbook of Research on Conceptual Change, Routledge 2008, 259.