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CONTINUING EDUCATION IN BIOMECHANICS FOR PHYSICAL EDUCATION TEACHERS

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ABSTRACT
Biomechanics is an essential core science for understanding humanmovement and for professionals that teach movement like physical educationteachers. Mastery of biomechanics principles is not strong followingtraditional university instruction, and physical education teachers often reportnot using biomechanics in their professional practice. This paper proposes abiomechanics continuing education course for Brazilian physical educationteachers based on meaningful learning theory and the professional skill of qualitativediagnosis of movement. The main elements to be considered in planningpotentially meaningful learning such as student, content, teacher, context andevaluation were summarized and illustrated. With the implementation of this coursewe hope to elicit meaningful learning in essential biomechanical principles incurrent physical education teachers, improve their application of theseprinciples in professional practice, and contribute to improved biomechanicsteaching strategies in other biomechanics courses.Key-words: meaningful learning, qualitative diagnosis, constructivist, teaching, scaffolding.
Keywords: Continuing Education, Biomechanics, Education, Teacher.

INTRODUCTION

Biomechanics and other scientific subdisciplines of kinesiology are fundamental to professional practice in physical education throughout the world. Biomechanics "involves the precise description of human movement and the study of the causes of human movement" (Knudson, 2007, 1) integrating knowledge from biology and physics. Physical education teachers must integrate biomechanics with other kinesiology subdisciplinary knowledge to plan instruction and training in motor skills, reduce the risk of injuries during activity, and in the professional skill of qualitative diagnosis of human movement.

Despite the importance of biomechanics in teaching and diagnosing human movement technique (Knudson, 2013), many teachers do not consider or try to apply this knowledge in their classes. Corrêa (2004) interviewed Brazilian physical education teachers and found that even though they believed in the importance of biomechanics to their field, they described their use of this knowledge as "little or never" in daily professional practice.

The limited use of biomechanics by physical educators is likely a multifactorial problem. One important possible factor is the physical teacher's initial biomechanics experience in the introductory course. Mastering many biomechanical concepts is difficult and counterintuitive, given they are based on Newtonian mechanics that have been consistently shown to be counterintuitive for most physics students (Hake, 1998; Halloun & Henestes, 1985; McDermott, 1991; Redish, 1999). In many kinesiology programs throughout the world, many majors enter the biomechanics class without essential, prerequisite knowledge of human anatomy (Barlow 1997; Belmont 2010; Knudson et al 2003), mathematics (Knudson et al, 2003), or physics (Garceau, Knudson & Ebben, 2011; Vilas-Boas, 2001).

Introductory biomechanics courses are also often taught in large lecture settings, with only about 61% of students experiencing key concepts in a laboratory setting (Garceau, Ebben & Knudson, 2012). Common student complains include that they do not see the relevance in biomechanics content (Hamill, 2007) and the overly mathematical and quantitative methods used in the courses (Vilas-Boas, 2001). Some scholars believe that some of that poor attitudes about and mastery of biomechanics in physical education students is related to the instructional strategies commonly used (Lobo da Costa & Santiago, 2007; Vilas-Boas, 2001) and the behaviors and strategies to learn chosen by students (Belmont & Lemos, 2012; Hsieh & Knudson, 2008).

Despite numerous conferences on teaching biomechanics in kinesiology and publications since 1978, the actual research documenting learning biomechanical concepts is limited (Knudson, 2010). Studies that have examined student learning of biomechanical concepts have shown that student interest in the subject and perception of professional application can influence in their learning (Hsieh & Knudson, 2008; Hsieh, Mache & Knudson, 2012). Beyond a poor experience in introductory biomechanics and a fading memory, other factors that may limit physical educators use of biomechanics knowledge in their professional practice include access to advances in knowledge and relevant application examples. Most educators do not have funding for ease of access to journals or professional conferences to learn about new developments in biomechanics or their application. This theory to practice gap is also exaggerated by a lack of university support for scholars to write application articles for physical educators (Knudson, 2005; Sanders & Sanders, 2001). Teachers often perceive that application articles are unintelligible because emphasis on specific scientific terminology and vague reference to specific uses in real-world problems faced by physical educators (Knudson, 2013).

Many physical educators do strive to improve professionally through informal collaboration with peers, professional publications, or reading of other sources on teaching and learning of motor skills. Given these efforts and some teachers pursuing graduate degrees, we believe there is an opportunity to develop targeted continuing education that could help improve understanding and application of biomechanics in physical education teachers. This paper proposes a biomechanics continuing education course for Brazilian physical education teachers based on meaningful learning theory (Ausubel, Novak & Hanesian, 1978; Gowin, 1981; Novak, 2010) and the professional skill of qualitative diagnosis of movement. We believe this theory and professional skill have potential to engage teachers with everyday professional problems they face and improve their understanding and application of biomechanics, and consequently their instruction. This paper will summarize meaningful learning theory, illustrate how this theory can be used to plan biomechanics instruction for physical educators, and potentially improve the teaching and learning of biomechanics concepts.

MEANINGFUL LEARNING THEORY

Meaningful learning theory provides an effective structure to address physical educators' difficulties in understanding learning and applying biomechanical concepts and principles. According to Ausubel, Novak and Hanesian (1978) meaningful learning occurs when the new information is linked with prior knowledge by student in a non-arbitrary (non-randomly) and substantive (non-literal) way. In essence, it is an assimilation process of new concepts in which both the new and the student's preexisting knowledge are modified. A meaningful learning experience requires two simultaneous conditions: the creation potentially meaningful material and the student's intentionality to learn in meaningful way.

These aspects of the theory may also partially explain the poor application of biomechanics concepts by students and physical education teachers. If the teaching situations in many biomechanics courses are perceived by students as unrelated to their current interests and future careers, they can have difficulties in attributing meanings to new concepts and avoid meaningful learning of biomechanical concepts. Ausubel (2000) postulates that the opposite approach to meaningful learning is rote learning that, occurs when new knowledge is arbitrarily linked to the learner's cognitive structure. In this case,

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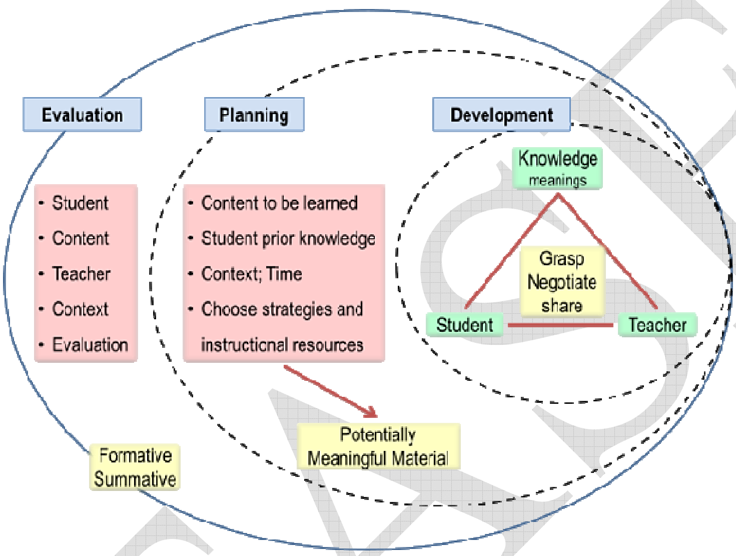
there is a weak connection or student seldom establishes linkage between new and specific prior knowledge. Therefore, rote learning or short-term memorization efforts promotes little or no acquisition of new meanings, frailty of the new concepts, with use limited to those situations that are very similar to the ones examined in class.

Within this framework, biomechanics instructors must consider that learning is a complex process which is influenced by several variables such as student, teacher, content, context and evaluation (Novak, 2010). These variables and their relationship are fundamental to developing three stages the creation of an instructional course: planning, development and evaluation (Lemos, 2011). Figure 1 summarizes the teaching process and meaningful learning elements that biomechanics professors should consider in planning more effective instruction. This model is illustrated in this proposal for a



continuing education course in biomechanics for physical educators.

Figure 1. A model meaningful learning theory used to design the proposed continuing education course in biomechanics. Although the figure can be read from left to right side, each stage interacts with each other throughout the teaching-learning process. Final evaluation, that includes all variables, is fundamental to reformulated subsequent courses.

PLANNING A CONTINUING EDUCATION BIOMECHANICS CLASS

A 20-hour continuing education course in biomechanics based on meaningful learning theory was designed for Brazilian physical educators by alignment of the content with the objectives of physical education in Brazil (Brazil, 1997). The course plan was also based on scholar proposals of pedagogical goals for physical education in Brazil (Betti & Zuliane, 2002; Ferreira, 2001).

The biomechanics course objectives were:

(1) Helping teachers to realize biomechanics importance to physical education practice;
(2) Engaging physical educators in learning general biomechanics concepts and principles that influence human movement;
(3) Illustrating the use of these general biomechanical concepts in the professional skill of qualitative diagnosis of the movements of pre-college students in physical education classes.

To reach these three objectives the proposed course focuses on qualitative concepts of biomechanics and qualitative diagnosis of human movement (Figure 2). The four tasks of the qualitative diagnosis of human movement (QDM) model formulated by Knudson (2013) and five of the nine biomechanics principles (Knudson, 2007) serve as the target concepts for the course (Figure 2). Many scholars recommend greater emphasis in qualitative diagnosis in biomechanics instruction for physical educators rather than an emphasis of quantitative problem solving (Knudson, 2003; Lobo da Costa & Santiago, 2007; Pinheiro, 2000; Vilas-Boas, 2001). Because biomechanics is normally considered difficult by most physical educators, its concepts will be introduced together within the evaluation and diagnosis task of QDM as real-world issues in teaching movement. In this way, integrating biomechanics concepts with QDM, teachers will be the opportunity to understand the causes of movements and relate them to daily situations in teaching physical education. According to meaningful learning theory, it is more important teach few essential concepts in a varied way than many of them in restricted situations. Since the course will be limited to twenty hours, biomechanics principles were chosen to focus on the essential concepts of both kinematics and kinetics of movements commonly taught in physical education.

Planning potentially meaningful teaching requires identifying students' prior knowledge. This can be done in many ways, but according to meaningful learning theory the most important aspect is recognizing the student's meanings of concepts specifically related to the new content that will be taught. In the proposed course, physical educator prior knowledge will be diagnosed at first class through a pre-test and if necessary, the course plan will be adjusted.

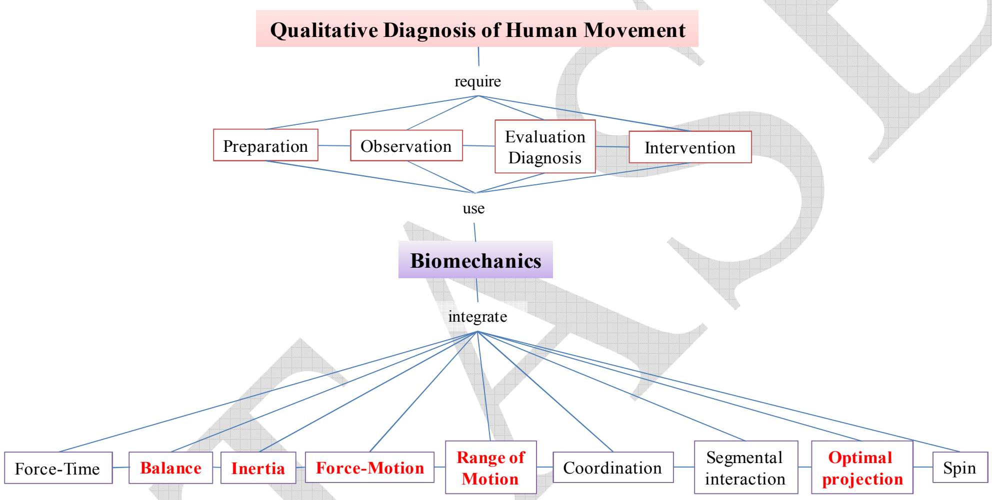


Figure 2. Concept map of qualitative diagnosis and the target principles of biomechanics being taught. Due to the brief duration of the proposed the biomechanics principles in red will be emphasized.

To help physical educators to perceive the relation between biomechanics and their professional practice, real-world human movement problems will be proposed according to the progressive differentiation principle (Ausubel, 2000). Table 1 shows how the course moves from more general and inclusive concepts to progressively embodying new and more specifics concepts. The sequential organization principle (Ausubel, 2000) will be used to formulate the set of problem questions that are sequence dependent, and the integrative reconciliation principle (Ausubel, 2000) will be used during classes exploring similarities and differences in a recursive way between prior and new concepts.

Table 1. General plan for 20-hours of continuing education in biomechanics.

Qualitative Diagnosis of Human Movement	Biomechanics	Students work at class	Students work at home
PREPARATION • Knowledge of performers. • Movement goals. • Essential features.		a) Pre-test (diagnosis evaluation) b) **Volleyball underhand serving** **Material:** Text about essential features and internet. **Problem-situation1 part 1:** Suppose that you are teaching volleyball underhand serving to student at elementary school for the first time. What are the important factors that your student should do to carry the serve out with safety and effectiveness? Think	

• Terminology of Human Movement • (Safety, Effectiveness and Efficiency Rationale).		about between four and eight factors and don`t forget to consider the goal of movement. **Individual answers:** (10min). **Answers in small groups:** (10min) Discussing about essential features and movement goal Comparing answers and elaborating one. **All students:** (10 min) Comparing answers among groups and build one conclusion with the professor.	
OBSERVATION • Gestalt approach. • Focus on critical features. • How control the situation. • Vantage points. • Number of observations. • Extended observation. • Written plans. • How to record movements. • Using free software.	Anatomical planes and axis of motion.	c) **Volleyball underhand serving** **Material:** Cameras and computers with free software. **Problem-situation1 part 2**: What is the best way to make the observation and record this movement? Consider as many points as possible from observation phase and make it justifying your answer. **Answers in small groups:** (15 min) **All students:** (10 min) Comparing answers among groups and build one conclusion with the professor.	**Final work step 1**: In pairs, choose a new movement from Physical Education context and make the preparation and observation. Remember that you are expected to justify each step.
EVALUATION/ DIAGNOSIS • Definition and objectives. • Formative and Summative. • Strengths and weaknesses points. • Sequential and mechanical method. • Using the critical features. • Knowledge about movements. • Identify problems.	• Force-Motion • Range of Motion • Optimal Projection • Inertia • Balance	d) **Review biomechanics principles** **Material:** Books and websites **Problem-situation2**: Why people move? What make movement of people possible? **All students**: (05min) **Answers in small groups**: (15min) You have three concepts: Force, Weight and Inertia. Using these 3 concepts, choose one movement in Physical Education context and make an explanation about how it occurs. **All students:** (10min) Comparing and discussing answers among groups. e) **Volleyball underhand serving** **Material:** Books and websites. **Problem-situation1 part 3**: Identify and explain how these 5 biomechanics principles occur to cause the body and ball movements and how do these inform your critical features. **Answers in small groups:** (15min).	**Final work step 2:** After you have made the preparation and observation, make the evaluation and Diagnosis based on Biomechanics concepts. Remember that you are expected to justify each step.

	All students: (10 min) Comparing answers among groups and build one conclusion with the professor. f) **Volleyball underhand serving** **Material**: Books and websites. **Problem-situation1 part 4:** Make the evaluation and Diagnosis justifying possible inadequateness with Biomechanics concepts. **Answers in small groups:** (15min) **All students:** (10min) Comparing answers among groups and build one conclusion with the professor.	
INTERVENTION • Feedback. • Visual models. • Exaggeration or Overcompensation. • Modification of Practice. • Manual and Mechanical Guidance. • Conditioning. • Attentional Cueing. • Ecological intervention.	g) **Volleyball underhand serving** **Problem-situation1 part 5:** Choose the intervention and justify its. **Answers in small groups:** (15min). **All students:** (10min) Comparing answers among groups and build a conclusion with the professor.	**Final work step 3**: After you have made the evaluation and diagnosis, choose the appropriate intervention. Remember that you are expected to justify each step.
	h) **Final work step 4**: presentation and discussion among students and the professor. i) Post-test	

EFFECTIVE INTERACTIONS WITHIN THE CLASS

Since the potential to facilitate meaningful learning depends on the organization of subject and the logic and coherence in which course concepts can be related with students` cognitive structure, the instructor will use problem solving strategies with expository moments. In this context, students will be encouraged to think with and about biomechanical principles through many practical examples, and will be assisted in making connections between principles and their various applications. Although instructional strategies such as negotiation of meanings involved in real-world problems and others may be new and challenging to many students, instructors must mediate these teaching situations and help learners to build the knowledge. To avoid memorization practice, often used by pre-college students, the QDM examples must be difficult enough in context and possible intervention that memorization alone is inadequate. Furthermore the teacher will be performing continuous formative evaluation to identify student's meanings and when they are temped to use memorization strategy. The instructor will intervene to help them make connections among concepts and modify their learning strategies.

This course plan gives students the opportunity to ask and answer questions, as well as argue and create hypotheses to explain the biomechanical principles and movement examples. To promote the negotiation of meanings (Gowin, 1981) and stimulate learners to think about and with knowledge, the instructor will answer many of student questions with another question or ask to other students to answer their classmates` questions. Questions are an important instructional strategy, however, two studies have reported that there was no significant association between the number of questions students asked instructors and measures of learning (Belmont & Lemos, 2012; Hsieh et al., 2012). The nature of questions seems to be the essential point. To develop improved questions, create hypothesis, and build arguments to support their ideas, students need to interact with knowledge as long as possible and the teachers are important guides in this process.

In spite of teachers' responsibilities to create an active and meaningful learning environment, learners must also take responsibility in their learning. In the triad of student, teacher and content (Gowin 1981), student and instructor must interact, negotiating meanings of content grasped by student intentionally, and sharing these meanings with each other. Gowin (1981) postulates that the choice "to learn a grasped meaning is a responsibility of the learner that cannot be shared" (63), then, the student decides whether learn or not in a meaningful way.

EVALUATING THE COURSE

Evaluation is an essential element of instruction and learning (Ausubel, Novak & Hanesian, 1978; Novak, 2010). To evaluate the students' progress in the course, both formative and summative evaluation data will be collected during the course, specifically focusing on how students apply their biomechanics knowledge.

Meaningful learning is quite difficult to confirm, however it is necessary pay attention on specifics evidence (Ausubel, 2000). This course plan proposes different real-world situations and activities in evaluation from those used in class. In formative evaluation, the professor will qualitatively note how students negotiate meanings with others students and with the teacher through verbal questions and course examples. The sequential organization of plan effectiveness, teaching strategies, and the instructional recourses chosen will also be assessed. Summative evaluation will be based on the pre and post-tests. The pre-test will include problem situations and open-ended questions, will be reviewed and validated by six university faculty with experience in introductory biomechanics courses. The post-test will include both pre-test questions and new questions of the same content in different situations. These tests will be used document the normalized learning of course participants (Hake, 1998; Knudson et al., 2003).

Besides students learning and the performance of teacher, the other elements that influence in teaching and learning such as the material elaborated, the context, and the evaluation strategies and tests will be qualitatively evaluated (Figure 1). All these evaluation results will document whether the course objectives were reached and gather information to reformulate the plan of teaching.

This paper proposed a continuing education program of biomechanics for Brazilian physical education teachers using meaningful learning theory. The professional skill of qualitative diagnosis of human movement served as the model for engaging teachers in learning biomechanical principles and their application in physical education. Future research will focus on the implementation of this continuing education model and documenting its effectiveness. If the course is successful in improving physical educators` mastery and application of biomechanical concepts, this model may provide biomechanics instructors with an important pedagogical strategy to improve the mastery of biomechanics concepts by students and physical educators.

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REFERENCES

Ausubel, D.P. (2000). *The acquisition and retention of knowledge: a cognitive view*. Boston: Kluwer Academic Publishers.
Ausubel, D.P., Novak, J.D., & Hanesian, H. (1978). *Educational psychology: a cognitive view*. (2thed.). New York: Holt, Rinehart and Winston.

Barlow, D.A. (1997). Interactive approaches to the study to the dynamics of human anatomy. In J.W. Wilkerson, K. Ludwig, & M. Boucher (Eds) *Proceedings of the fourth national symposium on teaching biomechanics* (pp. 13-20). Denton, TX: Texas Woman's University.

Belmont, R.S. (2010). *Unfolding/advancement of meaningful learning in biomechanics in the initial stages of the development of physical education teachers*.Master dissertation, Oswaldo Cruz Foundation, Rio de Janeiro, Brazil.

Belmont, R.S. & Lemos, E.S. (2012). A intencionalidade para a aprendizagem significativa da Biomecânica: reflexões sobre possíveis evidências em um contexto de formação inicial de professores de educação física. *Ciência & Educação* 18, 123-141.

Betti, M. & Zuliani, L.R. (2002). Educação Física escolar: uma proposta de diretrizes pedagógicas. *Revista Mackenzie de Educação Física e Esporte* 1, 73-81.

Brazil. (1997). Brazilian National Curriculum Parameters: physical education. Brasília: MEC/SEF. http://portal.mec.gov.br/seb/arquivos/pdf/livro07.pdf

Corrêa, S.C. (2004). A Biomecânica como ferramenta de intervenção na prática profissional. In *Proceedings of 27th International Symposium of Sport Sciences*, (p. 290). São Paulo: CELAFISCS.

Ferreira, M.S. (2001). Aptidao fisica e saúde na educacao fisica escolar: ampliando o enfoque. *Revista Brasileira de Ciencias do Esporte* 22(2), 41-54.

Garceau, L., Knudson, D., & Ebben, W. (2011). Fourth North American survey of undergraduate biomechanics instruction in kinesiology/exercise science. In J.P. Vilas-Boas, M.L. Machado, W. Kim, & A.P. Veloso (Eds.) *Proceedings of the 29th Conference of the International Society of Biomechanics in Sports* (pp. 951-954). Porto: University of Porto.

Garceau, L.R., Ebben, W.M., & Knudson, D. (2012). Teaching practices of the undergraduate introductory biomechanics faculty: a North American survey. *Sports Biomechanics,* 11(4), 542-558.

Gowin, D.B. (1981). *Educating*. New York: Cornell University Press.

Hake, R.R. (1998). Interactive-engagement versus traditional methods: a six thousand student survey of mechanics test data for introductory physics. *American Journal of Physics,* 66, 64-74.

Halloun, I.A., & Henestes, D. (1985). The initial knowledge state of college physics students. *American Journal of Physics,* 53(11), 1043-1055.

Hamill, J. (2007). Biomechanics curriculum: its content and relevance to movement sciences. *Quest,* 59, 25-33.

Hsieh, C., & Knudson, D. (2008). Student factors related to learning in biomechanics. *Sports Biomechanics* 7(3): 398-402.

Hsieh, C., Mache, M., & Knudson, D. (2012). Does student learning style affect performance on different formats of biomechanics examinations? *Sports Biomechanics*, 11, 108-119.

Hsieh, C., Smith, J., Bohne, M., & Knudson, D. (2012). Factors related to students' learning of biomechanics concepts. *Journal of College Science Teaching,* 41(4), 83-89.

Knudson, D. (2003). An integrated approach to the introductory biomechanics course. *The Physical Educator,* 60(3), 122-133.

Knudson, D. (2005). Evidence-based practice in kinesiology: the theory to practice gap revisited. *The Physical Educator,* 62(4), 212-221.

Knudson, D. (2006). Biomechanics concept inventory. *Perceptual and Motor Skills,* 103, 81-82.

Knudson, D. (2007). *Fundamentals of biomechanics*. (2thed.). New York: Springer.

Knudson, D. (2010). What have we learned from teaching conferences and research on learning in biomechanics? In R. Jensen, W. Ebben, E. Petushek, C. Richter, & K. Roemer (Eds.). *Scientific proceedings of the 28thconference of the international society of biomechanics in sports* (pp. 678-681). Marquette, MI: Northern Michigan University

Knudson, D. (2013). *Qualitative diagnosis of human movement: improving performance in sport and exercise.* (3thed.). Champaign: Human Kinetics.

Knudson, D., Noffal, G., Bauer, J., McGinnis, P., Bird, M., Chow, J., Bahamonde, R., Blackwell, J., Strohmeyer, S., & Abendroth-Smith, J. (2003). Development and evaluation of a biomechanics concept inventory.*Sports Biomechanics*, 2(2), 267-277.

Lemos, E.S. (2011). Aprendizagem Significativa: estratégias facilitadoras e avaliação. *Aprendizagem Significativa em Revista* 1, 25-35.

Lobo da Costa, P.H., & Santiago, P.R.P. (2007). Fundamentos de Biomecânica: fundamentos de ensino na licenciatura em educação física. *Revista Mackenzie de Educação Física e Esporte*, 6(2), 121-131.

McDermott, L.C. (1991). Millikan lecture1990: what we teach and what is learned-closing the gap. *American Journal of Physics*, 59, 301-315.

Novak, J.D. (2010). *Learning, creating, and using knowledge: concept maps as facilitative tools in Schools and corporations*. (2thed.). New York: Taylor & Francis.

Pinheiro, V.E.D. (2000). Qualitative analysis for the elementary grades. *Journal of Physical Education, Recreation & Dance*, 71, 19-20.

Redish, E.F. (1999). Millikan lecture: building a science of teaching physics. *American Journal of Physics*, 67(7), 562-573.

Sanders, R., & Sanders, L. (2001). Improving dissemination and application of sport science to physical educators. *Motriz* 7, s1-s5.

Vilas-Boas, J.P. (2001). Biomecânica hoje: enquadramento, perspectivas didáticas e facilidades laboratoriais**.** *Revista Portuguesa de Ciências do Desporto* 1, 48-56.