71 - ELECTRICITY GENERATION FROM BODILY MOVEMENTS

ELENISE SAUER
BRUNA LEAL
PATRICIA VANAT KOSCIANSKI
UTFPR, Ponta Grossa, Paraná, Brasil
sauer@utfpr.edu.br

doi:10.16887/88.a1.71

Introduction

Energy is a term widely used in the description and explanation of everyday facts, often covered in news about constructions of hydroelectric and thermoelectic plants, oil prices, use of renewable energy sources and nuclear energy risks (BUCUSSI, 2007). Presents itself in different forms in nature, mechanical energy, chemical energy, nuclear energy, thermal energy, light energy, magnetic energy, electrical energy and it has been studied since the elementary school in science education.

In science education, energy occupies a special position to consider that, for a long time, its genesis was beyond human comprehension. There is no claim in this article to delimit a concept of energy to one of the natural sciences but in the understanding of the concept through its meanings (ARAÚJO; NONENMACHER, 2009), and not to delimit as one more reference in the creation of epistemological obstacles (BACHELARD, 2008).

In the course of teaching in science education, with the goal of a contextualized approach on the subject of energy, we began a search for scientific texts to compose the teaching sequence, planned for the academic semester, in the absence of the subject in the textbook adopted (LOPES, 2015).

Reading alternative text can have great contribution in the process of teaching and learning about energy, when considering that enables the formation of a citizen with conditions to reflect, to relate to social, economic, technological and scientific aspects and different dimensions (ASSIS; TEIXEIRA, 2003).

As the context of the classroom stands out by the students' hectic behavior and to consider positive results demonstrated in learning activities that allow movement, it was enhanced the intention to find a context permeated in the movement, in this specific case, electricity genaration from body movements.

This decision is based on the intention to stimulate the production of subsumptions called "anchors" for the meaningful learning to occur, as the learning theory by David Ausubel (2000), which the ideas represented by symbols interact of substantive and non-arbitrary way with what the learner already knows (MOREIRA, 2012).

It is understood that pedagogical practices are essential for the formation of these cognitive structures, among which stands out the background and the relevance of the evidence of use, regardless of its area of knowledge. Also, it is provided in the national education curriculum guidelines for all curricula of basic education, in order to facilitate the dialogue between the different fields of knowledge to the same extent the transversality of knowledge in different disciplines, as well as the study and development of projects, related to specific topics of the reality of the students (BRASIL, 2013).

To establish contextualised relations it is necessary the teacher's domain in different pedagogical practices, adopting an integrated approach to learning in reference to another style of teaching, as claim Moreira; Caleffe (2008), both in conceptual dimension, specific or other scopes, which allow students to build structures that assign meaning to knowledge with emphasis not only on the cognitive domain, but in their social and technological relations.

In this line of argument, it is justified the importance of reading and discussion of texts, as activity distributed throughout of didactic sequences designed by the teacher. As the arguments presented a survey of literature review, whose goal was to build foundations of scientific content regarding bodily movements in the production of electrical energy in a multidisciplinary breadth of knowledge.

Theoretical Review

Production of electrical energy from the movement

At this point is significant to consider that electric power is a form of energy that can be transformed, quickly and efficiently, in any other, as in termal, luminous, mechanical and chemical energy. It is also important to instigate students to produce a list of examples related to your everyday life and what would be the consequences in its absence.

To prospect that electric power is transportable to distant regions for residential, commercial, industrial, rural or urban and what are the scientific, social, technological, economic implications and other scopes.

To abstract that two drivers transporting electrical energy from a source to the receiver, in a material way, in which the movement of the electrical loads occurs easily, called "conductors", formed by materials drawn from nature, such as copper, iron, aluminum, silver or in the reverse situation, in which the movement of loads is extremely difficult due to the molecular structure, the materials called "insulators or dielectric", consisting of rubber, porcelain, glass.

Also, to idealize that the electrical power source receives any form of energy and transforms it into electrical energy. As an example, we can mention the chemical energy in cells, batteries and accumulators; mechanical energy in dynamos and alternators; thermal energy in boilers; and other forms of energy: solar, geothermal, nuclear, piezoelectric, wind, photoelectric, thermionic and tidal wave.

Above all, conceptualizing that sources of electrical energy that use the movement, use the mechanical energy, and if this mechanical energy comes from a living creature, it is named biomechanical energy.

Production of electrical energy from body movements

The living species present numerous sources of mechanical energy, produced in the muscle stretching, balance of arms, legs, walking, jogging, heart rate and blood flow. This mechanical energy of living beings, the biomechanical energy, can be used in the production of electrical energy as described by Yang et al. (2009). In this line of research, there are studies of electric power production for different purposes.

Intelligent solutions are required to generate energy for a sustainable future. Many studies and researches are aimed at the development of reliable and affordable devices and techniques for generating electricity from natural sources, particularly in low power generation due to the mass consumption of electronic devices (RAMLI et al., 2014).

In this line of research, na electronic device was developed to convert mechanical energy into electricity from the vertical motion of a suspended load backpack (weighing 20 to 38 pounds), performed during a normal walk and that generated up to 7.4 watts, an increase of 300 times compared to the devices developed in previous phases. The generation of electricity in those conditions can help scientists in field workers, explorers and workers, and a very useful feature to replace heavy batteries in relief missions in places of difficult access, as well as in expanding the ability to operate instruments in remote areas (ROME et al., 2005).

Other research, developed by Yang et al. (2009) is a nanogenerator that converts the biomechanical energy, produced by the movement of a human finger, into electricity. The generator (SWG) is formed by a nano wire set on a flexible substrate, which under the lengthening of the muscle results in the stretching of the substrate and the nano wire, generating a piezoelectic potential, created within the yarn that takes the flow of electrons out of the circuit. The output voltage was increased to connect various SWGs, in a series with four SWGs produced an output voltage of up to 0.1-0.15 V. It were also carried out tests with a hamster racing, which revealed the potential to use the nanogenerator to avoid the low-frequency energy of regular and irregular biomotion.

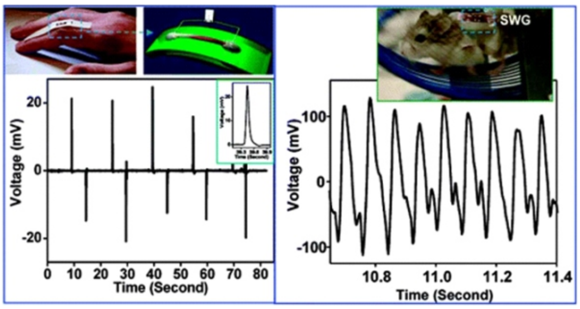

Figure 1 – Nanogenerator to convert biomechanical energy into electrical energy.
Source: Yang et al. (2009).

In a new perspective on the scenario of electric energy from body movement, researches have direct the development of membranes consisting of nanofibers, used for building triboelectic nanogenerators, prepared to collect biomechanical energy of high performance has enabled a rapid expansion in the business of calling wearable electronics.

In this line, nanofibers are stand out, made by polyurethane membranes, produced by electrospinning, process where the nanofibers are produced by electrostatic targeting directly on the polymer solution, in the form of membrane and fibers, called electrospun. The porous structure of the membrane "electrospun" is particularly important to the characteristics of its various properties (KHIL et al., 2003).

In this specific area, Ramakrishna et al. (2006) showed the development of nanofibers, capable of forming a highly porous with large mesh nets, produced by the surface/volume ratio, feature that improves performance for many applications. Electrospinning has the unique ability to produce nanofibers from different materials and in different configurations in the structure of the fibres. The relatively high production speed and simplicity of the stages of manufacture, make the eletrospinning highly attractive, both for academia and industry. As a result, a wide variety of nanofibers can be produced with different applications in healthcare, biotechnology, environment, engineering, defense, security and as a focus of this research, for collection and storage of electrical energy from the body movements (Figure 2).

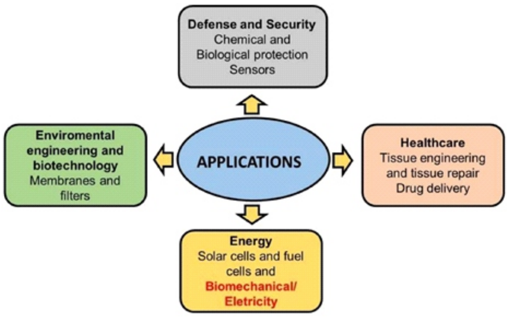

Figure 2 – Potencial applications of nanofibers.
Source: Adapted from Ramakrishna et al (2006).

In this context, the piezoelectric material is seen as a potential for power generation, due to its excellent property for conversion of kinetic energy into electricity. In this section, it has been developed a prototype called "Vibration Energy Harvester" (VEnH) to evaluate the performance of electricity generation from a source of vibration. This device works with "Piezoceramic" connected to a direct continue (DC) motor to pickup vibration produced by human steps, so that, when applying this continuous force in VEnH, it induces a deformation that produces electricity. The results showed that the output voltage was increased in proportion to the input offset, until it reaches a great condition, at about 5.4 Volts. These results indicate potential, reliability and robustness of power generation via VEnH, from the collection of energy originating from human activities (RAMLI et al., 2014).

Energy collection from biomechanical movement of a human being, represents a promising replacement for batteries, a reality where the portable devices discharging its batteries much faster than before. Thus, it was developed a device for collecting energy from vertical motion, generate by the heel of a person in a running cycle.

This device is different to convert the vertical motion in the rotational movement, generating energy from an engine of alternating current (AC). Power generation was increased by means of toothed gears, connected to an amplifier of the rotation movement, in a proportion of 27.5:1, so that reached an output of 1.1 W, along a running cycle. The collection of biomechanical energy under the presented conditions proved the ability to store energy in terms of extra effort, however, generates a discomfort to the user while using this device. This response related to discomfort directs that the need for energy collection should consider the criteria of comfort, to the same extent that develops a promising source of energy to connect modern appliances such as mobile phones and portable mp3 players (PURWADI et al., 2015).

It is also important to highlight the development of a triboelectric nanogenerator by Li et al. (2017), a source of light, flexible and sustainable energy, built with nanofibers (NM-TENG), capable of converting human biomechanics energy into electricity. The effective area of this device is 16 cm2, which can supply current and voltage, respectively, of 110 µA and 540 V, by gentle manual manipulation.

These membranes consisting of nanofibers, called "electrospun", were adapted to increase the triboelectric polarity, mechanical resistance and surface hydrophobicity, which resulted in improved performance, robustness and capacity of device operation even with high ambient humidity. The promising results of biomechanical energy collection from body movements to produce electricity using the wearable NM-TENG, were confirmed by means of sustainable food, a commercial thermal meter and about 560 lighting LEDs (Figure 3).

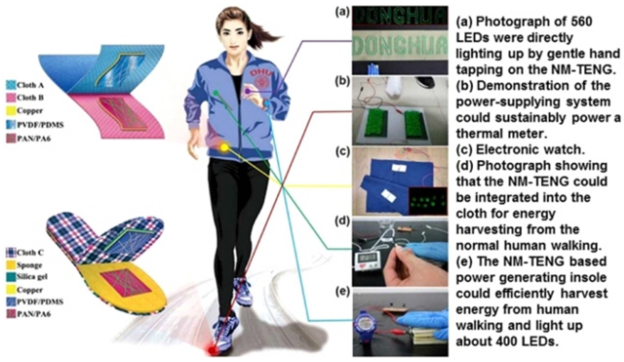

Figure 3 - Demonstration of NM-TENG to harvest various biomechanical energy from human body.
Source: Adapted from Li et al (2017).

Humans generate notable amounts of energy to perform daily activities, number corresponding to millions in specific units of energy, without collecting and exploiting, only dissipates in the environment. Alternatives to reverse this context are highlighted in the recent progress in the development of nanogenerators (NGs), devices that have the capacity to collect thermal and biomechanical energy, produced by physical triboelectric, piezoelectric and thermoelectric effects.

Within the process of creation of NGs, the comfort of the user must be included as main criterion, so this requirement accelerated the recent development of flexible materials with the ability to stretch for NGs and fabrics for the design of NGs (PROTO et al., 2017).

Important data on the efficiency in the generation of electrical power from body movements have been featured in recent research, by demonstrating that the effect of conversion depends on the amplitude and frequency (RAMLI et al., 2014). This information allows you to infer that everyday activities of humans can be used in the production of electrical energy.

The market forecasts for 2020, involving those technologies are promising, as highlighted by Proto et al. (2017), that the potential of commercialization of nanogenerators NGs, on grounds of innovation in the development of self-feeding devices.

In a near future, there are many perspectives on the evolution of the technologies presented in this review, regarding the possibility of building electronic devices powered by NGs that collect energy directly from the surface of the human body (PROTO et al., 2017). In this scenario, a person can be surrounded by a variety of wearable technology devices, electric energy self-feed by body movements, for different purposes such as sensors, radios, watches, GPS, among others (Figure 4).

1 Elenise Sauer, Av Monteiro Lobato, s/n - Km 04 CEP 84016-210 - Ponta Grossa, Paraná, Brasil. Telefone Geral +55 (42) 3220-4800, sauer @utfpr.edu.br

Figure 4 – Prospected image of wearable devices self-feeding for electric energy from body movements.
Source: Adapted from Rowe (2017).

Final Considerations

The human body produces a considerable amount of energy while performing daily activities, property that instigates research for development of efficient devices for collecting and converting this biomechanical energy into electrical energy.

Physical and chemical advances allow the development of flexible materials to design fabric that adheres to the surface of the body in the form of skin. These functional polymeric fibers are raw materials in developing of smart clothes for gathering energy on the surface of the human body, and represent a milestone in the use of electricity produced by human activity in the form of self-feed wearable devices.

The text presents theoretical content and images about the production of electricity from body movements, with potential for analysis, reflections and discussions on science education, enabling its inclusion in activities and strategies, geared to the contextualized approaches, reading and interpretation of scientific texts.

References

ARAÚJO, M.C.P.; NONENMACHER, S. Energia: um conceito presente nos livros didáticos de física, biologia e química do ensino médio. Poiésis. v. 2, n.1, p.1 -13, Jan./Jun. 2009

ASSIS, A.; TEIXEIRA, O. P. Algumas considerações sobre o ensino e a aprendizagem do conceito de energia. Ciência & Educação. v. 9, n.1, p. 41- 52, 2003.

AUSUBEL, D.P. The acquisition and retention of knowledge. Dordrecht: Kluwer Academic Publishers. 2000.

BACHELARD, G. A formação do espírito científico. 8. ed. Rio de Janeiro: Contraponto, 2008.

BRASIL. Ministério da Educação. Diretrizes curriculares nacionais da educação básica. 2013. 562p

BUCUSSI, A. A. Introdução ao conceito de energia / Alessandro A. Bucussi. – Porto Alegre: UFRGS, Instituto de Física, Programa de Pós-Graduação em Ensino de Física. 32p.: il. Textos de apoio ao professor de física / Marco Antonio Moreira, Eliane Angela Veit, ISSN 1807-2763; v. 17, n. 3, 2007.

KHIL, M-S; CHA, D-II; KIM, H-Y; KIM, I-S; BHATTARAI, N. Electrospun nanofibrous polyurethane membrane as wound dressing. Journal of Biomedical Materials Research Part B: Applied Biomaterials. v. 67B, Issue 2, Nov, p. 675–679, 2003.

LI, Z.; SHEN, J.; ABDALLA, I; YU, J; DING, B. Nanofibrous membrane constructed wearable triboelectric nanogenerator for high performance biomechanical energy harvesting. Nano Energy. n.36, p.341–348, 2017.

LOPES, S. Investigar e conhecer. Ciências da Natureza. Ed. Saraiva. 1ed, São Paulo. 2015.

MOREIRA, M. A. Al Final Qué Es Aprendizaje Significativo? Revista Qurriculum, v.25; marzo, p. 29-56; 2012.

MOREIRA, H.; CALEFFE, L.; G. Metodologia de pesquisa para o professor pesquisador. Rio de Janeiro, ed. Lamparina, 2008. 245p.

ROME, L. C.; FLYNN, L; GOLDMAN, E. M.; YOO, T. D. Generating Electricity While Walking with Loads. Science. Sep, v. 309, n. 5741, p. 1725-1728, 2015.

PROTO, A; PENHAKER, M.; CONFORTO, S.; SCHMID, M. Nanogenerators for Human Body Energy Harvesting. Trends in Biotechnology, July, v. 35, n. 7, 2017.

PURWADI, A. M. L.; PARASURAMANB, S.; M.K.A.AHAMED KHANC,*, IRRAIVAN ELAMVAZUTHID. Development of Biomechanical Energy Harvesting Device using Heel strike. Procedia Computer Science. v. 76. 270 – 275. 2015.

RAMAKRISHNA, S.; FUJIHARA, K.; TEO, W-E; YONG,T; MA, Z.; RAMASESHAN, R. Electrospun nanofibers: solving global issues. Materialstoday. v. 9, n.3, March, p. 40-50, 2006.

RAMLI, M.H.M; YUNUS, M.H. M.; LOW, C. Y.; JAFFAR, A. Scavenging energy from human activities using piezoelectric material. Procedia Technology. n. 15. 827 – 831, 2014.

ROWE, K. Develop Wearable Devices on the IoT Cutting Edge. Eletronic Design. Founder and CEO, RoweBots Ltda. 2017.

YANG, R.; QIN Y.; LI, C; ZHU, G.WANG, Z. L. Converting Biomechanical Energy into Electricity by a Muscle-Movement-Driven Nanogenerator. Nano Lett., v.9, n.3, p. 1201-1205, 2009.

ELECTRICITY GENERATION FROM BODILY MOVEMENTS

The objective of this article is to present a research based on scientific and technological development of the electrity generation from body movements, a range of multidisciplinary knowledge, directed to academics and readers who seek scientific information. Emphasis to the possibility of inclusion in activities and strategies, geared to contextualized approaches, using reading and interpretation of scientific texts. The methodology consisted in analytical, interpretive and qualitative description of communications of the specialized literature. The text presents theoretical content and images about the production of electricity from body movements with potential for analysis, reflections and discussions in science education.

Keywords: bodily movementes, electricity generation, science education.

MOUVEMENTS CORPORELS DANS LA PRODUCTION D'ÉNERGIE ÉLECTRIQUE

L'objectif de cet article est de présenter une recherche fondée sur le développement scientifique et technologique, sur l'utilisation des mouvements corporels pour la production d'énergie électrique, dans une gamme de connaissances pluridisciplinaires, dirigé vers l'environnement académique, et / ou vers les lecteurs qui cherchent de l'informations scientifiques. L'importance est réalisé sur la possibilité de les inclure dans des activités et des stratégies adaptées à l'approche contextualisée, qui d'utiliser la lecture et l'interprétation de textes scientifiques. La méthodologie consistait en une description analytique, interprétative et qualitative des communications dans la littérature spécialisée. Le texte présente des contenus théoriques et des images, concernant la production d'énergie électrique, à partir de mouvements corporels, avec des potentialités d'analyse, des réflexions et des discussions dans l'enseignement des sciences.

Mots-clés: mouvements corporels, énergie électrique, enseignement des sciences.

MOVIMIENTOS CORPORALES EN LA GENERACIÓN DE ENERGÍA ELÉCTRICA

El objetivo de este artículo es presentar una investigación basada en el desarrollo científico y tecnológico sobre la utilización de movimientos corporales para la generación de energía eléctrica, en una perspectiva multidisciplinaria, dirigido al medio académico y a lectores que buscan informaciones científicas. Se destaca la posibilidad de su inclusión en actividades y estrategias con enfoques contextualizados que utilicen lectura e interpretación de textos científicos. La metodología consistió en la descripción analítica, interpretativa y cualitativa de comunicaciones de la literatura especializada. El texto presenta el contenido teórico e imágenes acerca de la producción de energía eléctrica, a partir de movimientos corporales, con potencialidades para el análisis, reflexiones y discusiones en la enseñanza de las ciencias.

Palabras clave: movimientos corporales, energía eléctrica, enseñanza de ciencias.

MOVIMENTOS CORPORAIS NA GERAÇÃO DE ENERGIA ELÉTRICA

O objetivo deste artigo é apresentar uma pesquisa fundamentada no desenvolvimento científico e tecnológico, da utilização de movimentos corporais para geração de energia elétrica, numa abrangência de conhecimento multidisciplinar, direcionado ao meio acadêmico, e ou, a leitores que buscam informações científicas. Ênfase se faz para a possibilidade de sua inclusão em atividades e estratégias, orientadas às abordagens contextualizadas, que utilizem leitura e interpretação de textos científicos. A metodologia consistiu na descrição analítica, interpretativa e qualitativa de comunicações da literatura especializada. O texto apresenta conteúdo teórico e imagens, a respeito da produção de energia elétrica, a partir de movimentos corporais, com potencialidades para análise, reflexões e discussões no ensino de ciências.

Palavras chave: movimentos corporais, energia elétrica, ensino de ciências.