Drawing, virtual modeling and 3D print in the production of didactic models for the teaching-learning of visually impaired students: case study of nanostructured systems

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Abstract

The present study focused on the inclusion of visually impaired individuals in regular and special need education based on the proposal of educational resources to be applied in different disciplines. This study case involved the development of models of nanostructured systems. The production of these models included image design and stylization, 3D virtual modeling and 3D print. The representation techniques used in this study generated a didactic kit for the teaching of nanostructured systems. The proposed models can be used for both sighted and visually impaired students, whether blind or with low vision.

Keywords: drawing; virtual modeling; 3D print; didactic models; visual impairment; nanostructured systems.

1 Introduction

In recent decades, social mobilization has been increasing to raise awareness of the different demands of individuals with special needs. For Bruno and Mota (2001), the social model of disability becomes a bilateral process in which the active participation of individuals and the system pursue the formation of a society for all. Legislation and policies include the right to education of persons with disabilities. Education should be a priority to allow individuals to have access to knowledge and therefore, proper ownership of the history and culture (Batista & Menezes, 2008).

The educational institutions can help the individuals to face the challenges imposed by their disability and build partnerships in the fight for inclusion. In these settings, some topics such as prejudice, myths and stigmas are experienced and discussed. However, some precaution should be taken to avoid minimizing the potential and the conditions of those individuals (Gil, 2000; Bruno & Mota, 2001). To do so, these institutions should adapt their pedagogical practices in order to meet every need specifically.

With regard to visually impaired individuals, some educational resources such as books in Braille, magnification techniques that enlarge text, and voice synthesizer software that reproduces the text as speech, are very well established. These individuals have a great sense of touch and the objects with different sizes and textures provide sensations capable of generating mental images that are important for communication, aesthetics and concept formation (Sá, Campos, & Silva, 2007). However, the resources mentioned above proved to be ineffective in the teaching-learning process of certain contents, because not everything that is seen through the eyes is within reach of the hands. Thus, how can we establish a method for teaching-learning the planetary system or the microorganisms, for instance, to visually impaired students?

Therefore, the present study focused on the inclusion of visually impaired individuals in regular and special need education based on the proposal of educational resources to be applied in different disciplines. This study case involved the development of models of nanostructured systems. The following step-by-step procedure was used to generate these models: (i) understanding and concept of visual impairment, aspects related to inclusive education and criteria for the production of teaching resources; (ii) design and stylization of nanostructured systems shape; (iii) 3D virtual modeling; and (iv) 3D printing.

2 Visual Impairment: concepts, education and didactic models

The classification of visual impairment varies worldwide. The general classification of visual impairment includes blindness and low vision. The first case can be defined as a severe dysfunction with total loss of sight, including the absence of light perception. Low vision (also called amblyopic or residual vision) refers to the loss of visual acuity while retaining some vision. It may be caused by numerous factors which interfere with or limit the visual performance of the individual (Gil, 2000; Bruno & Mota, 2001; Sá et al., 2007; Santos & Manga, 2009).

The first attempts to educate people with visual impairment dated from the 16th century. In 1547, an Italian doctor named Girolamo Cardano described a tactile system for teaching the blind, similar to that later developed by Louis Braille. This system has gained worldwide popularity, including in Europe and in the United States. It consists of raised dots and dashes and allows the visually impaired to participate in common tasks. In 1850, the Braille system was brought to Brazil by José Álvares de Azevedo who worked to create an institution for the blind. However, the landmark in the history of education for the visually impaired was the creation of the Foundation for the Blind's book in Brazil in 1946. Nowadays, the Dorina Nowill Foundation for the Blind is a pioneer in the field and defends inclusive education (Bruno & Mota, 2001; Sá et al., 2007; Santos & Manga, 2009).

Regardless of the level of visual impairment to make an inclusive education possible, a joint effort in human resources training and the adaptation of teaching practices are necessary (Crós, Mataruna, Oliveira Filho, & Almeida, 2006). The haptic interface technology enables the visually impaired to recognize shapes and objects and to distinguish the exact position of the object in the space. According to Gil (2000), the human haptic system has two independent components: cutaneous and kinetic. This set of sensorial mechanisms, such as vibrations and tactile sensations, are interpreted by the brain and may provide valuable information.

Thus, the elaboration of didactic models should meet certain criteria, considering that they will be used constantly. Preference should be given to the materials that are pleasant to touch, do not cause skin irritation, and present a resistant surface with enough counterforce. These models should be produced in large scale to meet the simultaneous demands of a great number of students, to allow multiple experiences, as well as to address the fundamental aspects of tactile and/or perception (especially for those with low vision) for a more significant stimulus (Cerqueira & Ferreira, 2000; Sá et al., 2007).

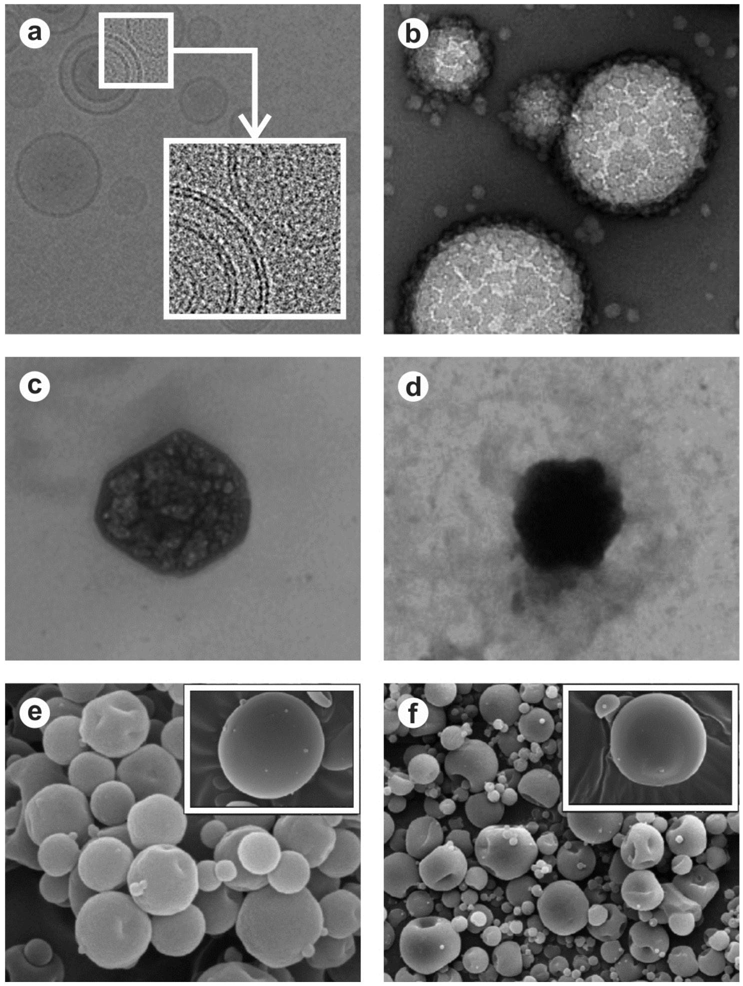
3 Case study: production of didactic models of nanostructured systems

Nanotechnology is the design, characterization, production, and application of structures, devices, and systems by controlled manipulation of size and shape at the nanometer scale (Moritz

& Geske-Moritz, 2013; Mihranyan, Ferraz, & Strømme, 2012). Wang et al. (2014) highlighted that this is one of the most innovative techniques of the century and has the potential to impact almost every area of society. Nanotechnology is based on the principle of surface area and volume of the materials, which interact with the surrounding environment differently than they would be if they were larger (Noronha, 2012; Boixeda, Feltes, Santiago, & Paoli, 2015; Safari & Zarnegar, 2014).

Until now, chemistry researchers recognize a variety of nanometric systems that differ with respect to composition. These systems include nanoliposomes, nanoemulsions, and nanoparticules. The nanoliposomes (Figure 1a) present a bilayer membrane lipid structure composed of phospholipids. The nanoemulsions (Figure 1b) are thermodynamically unstable colloidal dispersions formed by two immiscible ionic liquids, such as oil and water (O/W). The nanoparticles can be subdivided into solid lipid nanoparticles (Figure 1c), similar to the nanoemulsions (O/W), but the oil is replaced by a solid lipid; nanostructured lipid carriers (Figure 1d), which are produced from the mixture of solid lipids and liquid lipids, such as butter; nanocapsules (Figure 1e) in which a polymeric wall surrounds an oily core; and nanospheres (Figure 1f), which are formed by a polymeric matrix (SchaffazickI, Guterres, Freitas, & Pohlmann, 2003; Silva, 2004; Müller, 2007; Khan, Kotta, Ansari, Sharma, & Ali, 2012; Wang et al., 2014).

Figure 1: Photomicrographs of nanostructured systems.



(a) nanoliposomes; (b) nanoemulsions; (c) solid lipid nanoparticle; (d) nanostructured lipid carrier; (e) nanocapsules and; (f) nanospheres. Modified from Vironova, 2015a; Vironova, 2015b; Gokce et al., 2012; Yousaf et al., 2014.

Due to the high complexity and a subtle differentiation between these structures, it was observed that the photomicrographs were not clear enough to be used for educational purposes. Therefore, schematic drawings of the structures should be made to determine the basic differences between them. These drawings can be introduced as a teaching and learning resource for students without visual impairments, and can also be applied to create 3D virtual models. In turn, the digital files generated can be used in a 3D printer to create the didactic models of nanostructured systems for the teaching-learning of visually impaired students.

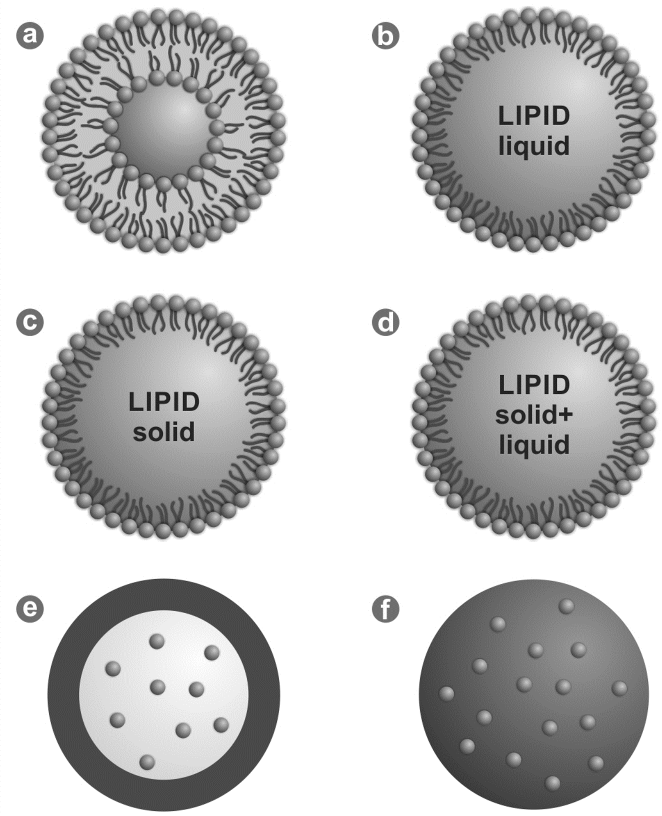
3.1 Drawing and stylization of forms

The stylization of form begins with the understanding of the parts that comprised each system. To do so, this information was analyzed in the production and/or characterization of items of the nanostructured systems.

It was found that the nanoliposomes, the nanoemulsions, the solid lipid nanoparticles, and the nanostructured lipid carriers are formed by phospholipids. The primary difference between these structures is their internal composition. The nanocapsules have their content protected from the external environment by a well defined wall, while the content of the nanospheres are dispersed into a matrix (SchaffazickI, Guterres, Freitas, & Pohlmann, 2003; Silva, 2004; Müller, 2007; Khan, Kotta, Ansari, Sharma, & Ali, 2012; Wang et al., 2014).

The two-dimensional schematic representation of the nanostructured systems was performed using the CorelDRAW® software (Figure 2). A gradient fill was applied in the systems to simulate the volumes of these structures. In addition, a text was inserted to describe the difference between the contents of the nanoemulsion, solid lipid nanoparticle and nanostructured lipid carriers.

Figure 2: Schematic drawing of nanostructured systems.



(a) nanoliposome; (b) nanoemulsion; (c) solid lipid nanoparticle; (d) nanostructured lipid carrier; (e) nanocapsule and; (f) nanosphere. Modified from SchaffazickI, Guterres, Freitas, and Pohlmann, 2003; Wang et al., 2014.

For the teaching and learning process of the students without visual impairment, the schematic drawings of the nanostructured systems were illustrative. The written indications represented the difference between the contents. For the students with visual impairment, the teaching-learning process with the use of schematic drawings is still not effective. Therefore, virtual models were proposed to allow the production of printed models.

3.2 3D virtual models

Three-dimensional virtual models in chemistry teaching-learning were incorporated in the early 1990. David and Jane Richardson introduced the Kinemage software which was used to model and give interactive graphic scientific illustration of molecules. Since then, several advances have been made to improve the educational resources available in the area. In 2013, Manuel

Moreira Baptista, as part of his PhD thesis, provided more than 80 three-dimensional animations[2] for chemistry teaching (Baptista, 2013). Approximately 1 million viewers from 148 countries have accessed the animations on the internet (Unicamp, 2013).

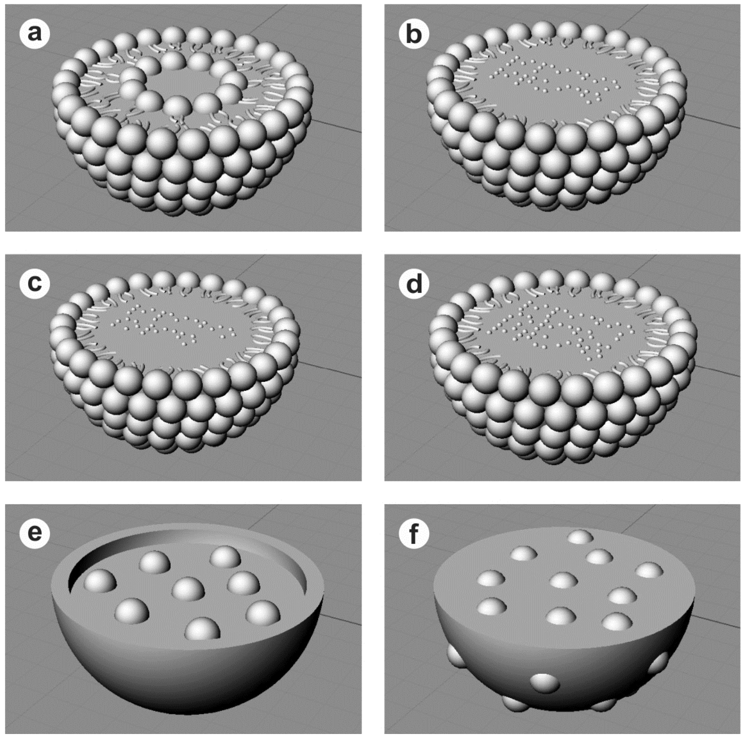
In the present study, the virtual 3D models were developed from two-dimensional representation by means of the Rhinoceros 3D® computer graphic software. A hemisphere was used as the basis representation of all models. On the surface of that volume, smaller spheres were placed to represent the phospholipids that form the nanoliposomes, the nanoemulsions, the solid lipid nanoparticles and nanostructured lipid carriers.

For the modeling of the nanoliposome core (Figure 3a), additional spheres were inserted to represent the bilayer of phospholipids, which characterizes this nanostructured system. The gradient fill was replaced by volumes to enhance the tactile aspects of the representation. To determine the different states of matter (solid and liquid), Braille inscriptions were added on the core surfaces of the nanoemulsion (Figure 3b), the solid lipid nonparticule (Figure 3c) and the nanostructured lipid carrier (Figure 3d).

For the representation of the nanocapsule (Figure 3e), it was necessary to model a slightly smaller sphere within the hemisphere. The difference between the diameters may serve as a shell for this nanostructure. As a result, the internal contents were represented by eight smaller spheres arranged randomly in the core. Finally, to create the nanosphere (Figure 3f), several small-size spheres were placed randomly over the entire surface of the volume.

[2] http://www.quimica3d.com/

Figure 3: 3D virtual modeling of nanostructure systems.



(a) nanoliposome; (b) nanoemulsion; (c) solid lipid nanoparticle; (d) nanostructured lipid carrier; (e) nanocapsule and; (f) nanosphere.

3.3 3D printing

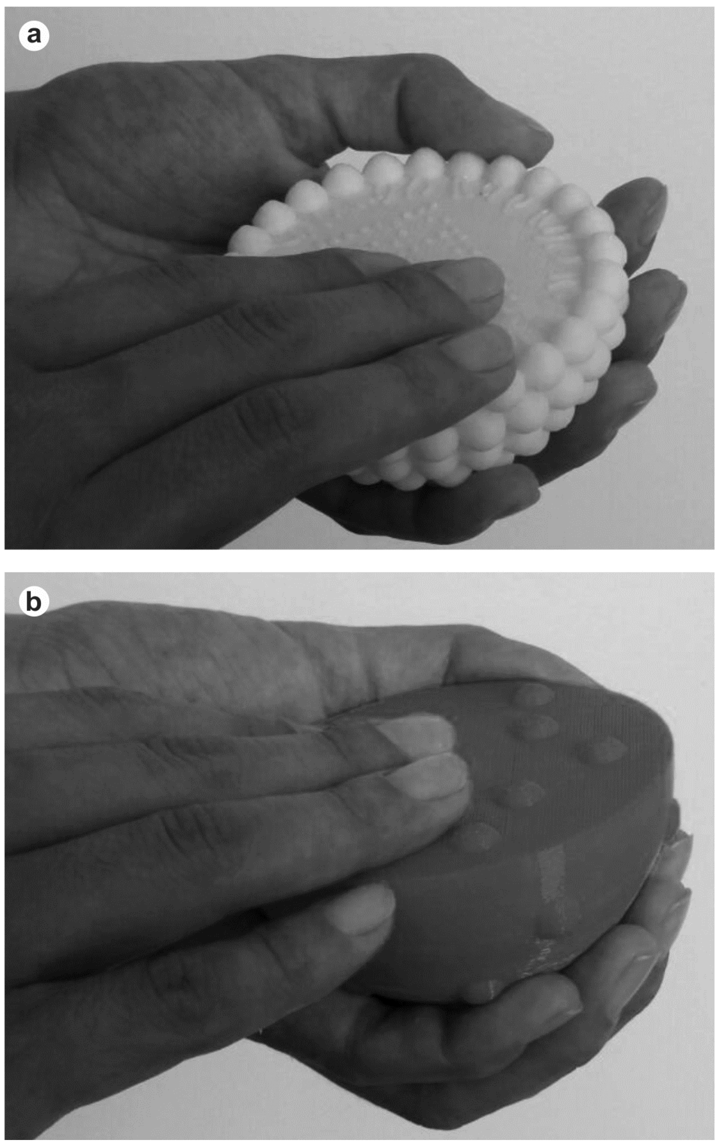
A 3D printing, also known as rapid prototyping (RP), is obtained using an additive process, which is based on laying down successive layers of material until the entire object is created. It starts with making a virtual design of the object to be created. This virtual design is made in a CAD (Computer Aided Design) software that enables the generation and manipulation of complex geometric shapes in 3D. With these software, it is possible assign different materials, textures, volumes and shapes to objects in order to analyze some features, such as assembling and disassembling of parts (Espinoza & Schaffer, 2004).

Rapid prototyping is a recent and innovative technology that has been used since the 1990s to produce relatively quick prototypes to test and review information, such as ergonomics, as the product develops (Hallgrimson, 2012). With this method, it is possible to transform geometrically complex digital models into physical artifacts.

In the present study, the models were developed using the 3D printer UP Plus 2, Sintetize 3D, which utilizes the fused deposition modeling (FDM) technology. The parts are produced by laying down material in layers; a thermoplastic filament (PLA - polyactic acid) is then heated and extruded.

Didactic models developed in this study (items 3.1 and 3.2) were printed (Figure 4). These models are important teaching aids for visually impaired students as they will allow them to have a better understanding of content and form.

Figure 4: 3D print of nanostructure systems.



3D printed models of (a) nanostructured lipid carrier and (b) nanosphere been manipulated by an adult.

4 Conclusion

The representation techniques used in this study made it possible to create a didactic kit for teaching nanostructured systems. The models can be used for both sighted and visually impaired students, whether blind or with low vision. The handling of parts facilitates the understanding of the structural dimensions and differences between the contents of the structures. The development of virtual models and 3D printing can be extended to other contents of science and even to other disciplines. It is worth mentioning that the access to the digital files is limitless, therefore, any educational institution can print the templates and use them as a didactic resource. This proposal helps meet the need for unity that should permeate the relationship between the educational and pedagogical practices in a school that intends to be inclusive.

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