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ATMK: A Monera Kingdom Atlas for Presenting Cell Morphology and Biotechnology for Visually Impaired Students

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Abstract

The teaching and learning process for approaching the scientific knowledge should allow the inclusion of all students especially those with blindness or visual impairment. In this work we produced a didactical material about Monera kingdom to allow the knowledge accessibility by all students including those with blindness or visual impairments. The Monera kingdom theme was selected due to its complexity and variety of examples about cellular morphology that also allow the approach of other topics such as biotechnology. Thus we produced an Atlas about bacterial morphology using paper with different textures to provide a tactile distinction to the student with visual impairment. The Atlas development involved four steps including: a) the Atlas preparation, b) *in locus* test with students with visual impairment, c) morphologies structural evaluation (2D to 3D) using modeling clay and d) analysis about student's opinion through an interview. The Atlas of the Monera Kingdom was produced and we observed that it had a stimulatory effect on blind and visually impaired students. The Atlas allowed the understanding of the microorganism's morphology with full content access for these students and also with the possibility of approaching biotechnology topics such as microorganisms and its biotechnological potential. These conclusions were reinforced by observing the three-dimensional analysis and evaluation of the questionnaire responses that pointed for the importance of this material for the public with special needs.

Keywords

Inclusive Education; Tactile Material; Visually Impaired; Blindness; Biology; Biotechnology

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1. Introduction

Schools that are ruled by the inclusion perspective have an obligation to recognize the different needs of all students, always adapting the teaching contents to attend them all. They have to ensure that everyone can achieve an appropriate level of learning using suitable educational programs and evaluative steps (Wilson, 2002; Patton et al., 2005; Kurawa, 2010; Delou et al., 2012).

Among the students with special educational needs are those visually impaired, which can be classified into three types: 1) blind, which has only light perception or no vision at all and need to use sight-independent educational tools; 2) individuals with severe visual impairment that have limitations on distance vision, but can see objects and materials as close to the eyes or two feet away at most; 3) individuals with moderate visual impairment, which are those that may have your problem corrected by surgery or by using eyeglasses (WHO, 2014).

The blind students must develop specific skills to understand any information that should be accurately offered to them. On that perspective, touch is one of the senses that must be continuously trained and may help in identifying tactile educational materials that present different textures, topographies, shapes and/or weight (Katz 1989; IBC, 2014). Current research reinforced the ability of blind individuals to recognize and understand two- and three-dimensional drawings embossed designs. Many studies have emphasized the benefits of interacting with 2D and 3D materials that provide spatial information for all students including those visually impaired (LIMA, 2005; Delou et al., 2012). On that perspective, the teacher/professor should use all information related to the remaining senses of these students such as hearing, smell, touch and taste to broaden the horizon of their learning opportunities (Delou et al., 2012).

The complexity of the issues in the field of biology is a challenge for any student, and especially for those with visual impairments that need a more focused teaching approach. Biological themes such as the Monera Kingdom generally require new approaches to guarantee the understanding of all contents involved. In case of Monera Kingdom, it includes bacterial morphology that is an important subtopic that needs different techniques to allow the full access and comprehension of the information by those with visual impairments.

The bacteria are the majority of microorganisms in the Monera Kingdom and have extreme importance with intense participation in nature and human life. Among these, the ecological relationships, recycling of nutrients in the decomposition of organic matter, participation in the Nitrogen Cycle, employment in the production of therapeutic drugs (such as antibiotics e.g. rifampin, neomycin), vitamins, hormones and insulin, manufacture of various enzymes; production of methanol and ethanol, and in the food industry, among others (Katz, 2011; Clarke, 2013). Therefore, the biotechnological potential of some of the members of this kingdom is of knowledge and should be recognized by all students.

The bacterial morphology features at microscopic and macroscopic levels are used to identify them and still are a key element in most identification methods used today (Wearing, 2010). Coccus can be grouped in pairs, being called diplococci, and when this group forms a chain of cocci, it is called Streptococcus. They may also appear as a "bunch of grapes", so-called Staphylococci. The bacilli may also be present in pairs, diplobaciles, or chains, streptobaciles, whereas the vibrios and espirils are found as isolated cells. The gram-positive bacteria Streptococcus pyogenes is an example, which forms long coccus chains and small white colored hemolytic colonies on blood agar plates (Wearing, 2010).

Since the understanding of the Monera Kingdom may help the students in different levels as citizens that should know about their world (e.g. Biotechnology) and health (e.g. microbiology), the main objective of this work was to produce a tactile material called *ATMK—Atlas of the Monera Kingdom* to be used as a tool for teaching students with educational needs, especially those with visual impairments.

2. Methodology

The production and evaluation of the Atlas of the Kingdom Monera were performed from a set of steps including:

- Preparation of the Atlas of the Monera Kingdom (ATMK).
- *In locus* test with visual impaired students.
- Evaluation of ATMK using clay and an interview.

2.1. Preparation of ATMK

The didactical material named ATMK (Atlas of the Monera Kingdom) was produced by using the following materials: Tracing paper (weight 110 g/m²), mark pen, fine-tipped marker pen (colors: red, green, pink, brown), Glue embossed (color: metallic green), Glue stick, EVA (color: yellow), Velvet Paper (color: orange), Corrugated Paper (color: blue), crepe paper (color: light pink), Line of stitching (color: blue), Ruler with capital letters for preparing the Legend, Scissors and Ruler of 30 cm.

Each cell morphology was characterized by using a specific paper texture and color to provide distinction for the student with visual impairment. As an example, the coccus that are basic units for the identification of diplococci, streptococci and staphylococci were produced using velvet paper, demonstrating the similarity among them. Herein we used some didactical textbooks for orienting the designing and representation of bacterial morphology to follow those used in the classroom. The bacterial morphology were reproduced in the form of: Coccus—rounded circumvented by mark pen; rods—elongated forms filled with crepe paper; vibrios—comma-shaped EVA; Spirils and Spirochetes—waveforms in corrugated paper using the sewing thread to demonstrate the flagella. All figures were captioned in both Braille and big bold letters.

2.2. *In Locus* Test with Students with Visual Impairment

As a second step, the didactical material was tested with 7th grade students (n = 6) from Benjamin Constant Institute, a national reference center of the education of visually impaired students (IBC, 2014). The test was conducted by randomly divided the six students into two groups in order to get the best experience with the Atlas. Each sheet was passed from hand to hand, on a rotating basis. As the sheets were visualized and touched, students talked to each other and compared their impressions.

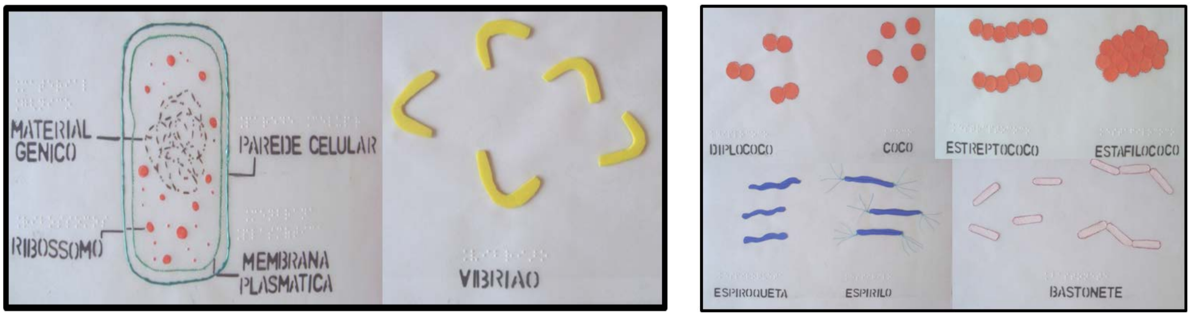
2.3. Evaluations of ATMK Using Clay and an Interview

In this work we have used plasticine, a non-toxic kind of clay, as a strategy for evaluating the students with visual impairment about their learning on bacteria morphological characteristics. Since bacteria were shown in our Atlas as a two-dimensional representation, so it was important to observe if they understood the 3D aspect implied. This would be notorious based on how they represent these morphologies using plasticine. Thus, a comparison between the morphologies present in the material and the student representations using clay would help to evaluate the consistency of the Atlas as a didactical tool.

Herein, we also used a questionnaire with four objective questions and one open question to evaluate the use of the Atlas, its advantages and impact on teaching and learning of students of an inclusive classroom. The students answered the questionnaire orally, which was conducted as an interview.

3. Results and Discussion

The Atlas was produced using 6 paper sheets (weight of 110 g/m²) and different types of paper, glue, sewing lines and colors that allowed representing the main bacteria morphologies. The purpose was to help students to understand how the bacteria are formed, their organelles, structures, and genetic material (**Figure 1**). The most important of this material is that can be produced with any kind of paper or even tissue with low cost, depending



(a) (b)

Figure 1. The Atlas of the Monera Kingdom. (a) Complete morphology of a bacterium with an inside view including structures, cell wall, plasma membrane, genetic material and organelles; captions in Braille and enlarged letters are included. On the right, vibrions are made of yellow EVA. (b) Morphology of diplococci, coccus, streptococci and staphylococci (showed with the same color and texture), spirillum spirochete (corrugated paper and flagella of sewing line) and rods in light pink.

only of the maintenance of the representation of bacterial diverse characteristics.

Evaluation of the Atlas of the Monera Kingdom

In this work, we tested the Atlas with students (n = 6) from Benjamin Constant Institute (IBC), a school specialized in attending visual impaired students. The group that voluntarily participated of this study, was composed with three blind students and three students with severe visual impairment (**Figure 2**).

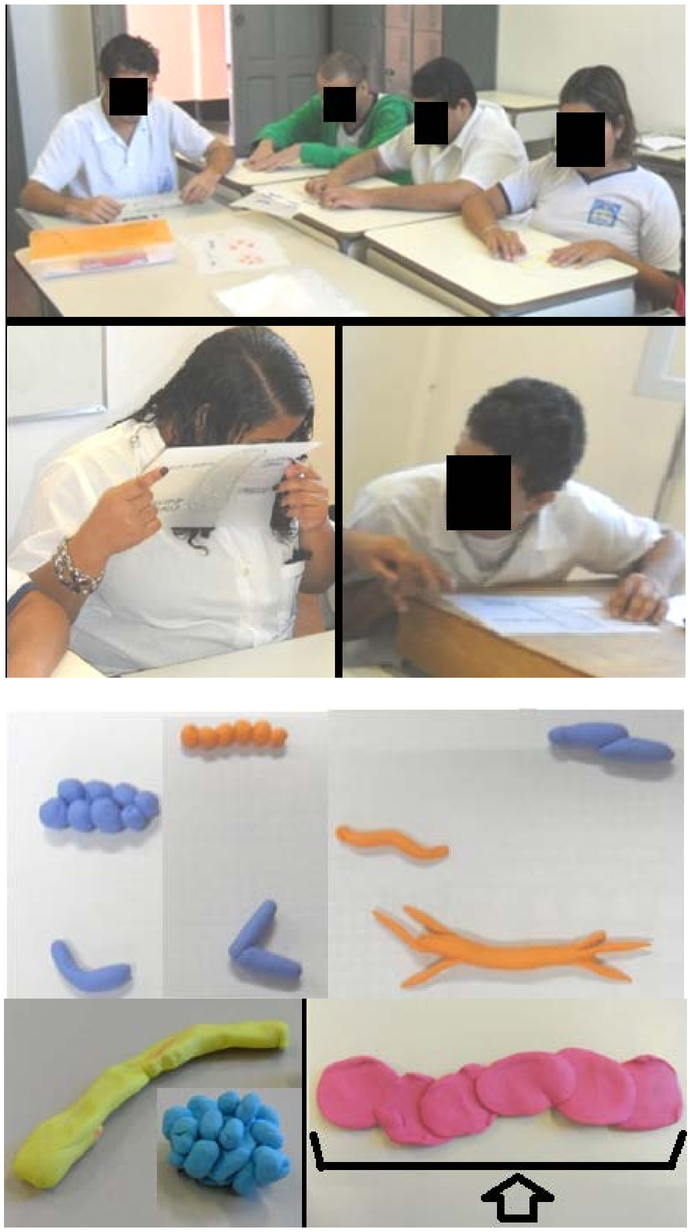


Figure 2. The *in locus* test of the Atlas of Monera Kigdom with the group of students (n = 6) from Benjamin Constant Institute (IBC), including three blind students and three with severe visual impairment (up). Comparison of the 3D-representation of the bacterial morphology produced by the group using plasticine (clay) after exploring the Atlas. The arrow points to the flat-representation of streptococci made by the visually impaired student who had difficulties in understanding the 3D perspective implied by the material (down).

We initiated the *in locus* test by asking the whole group about their previous concepts regarding bacteria and bacterial morphology and their previous contact with the topic at school. In the group, only one student already had some contact with a tactile material about bacteria but could not remember what it was like. The concepts of prokaryotic and eukaryotic organisms were also not remembered as well as if the bacteria were uni- or multicellular organisms. Therefore, we used a question-answer oriented conversation to gradually present the Monera Kingdom content to the group, which was divided into two groups of three. Each student has received a different bacterial morphology sheet, which they switched and compared with each other also sharing their perceptions (**Figure 2**).

After presenting the Atlas for the students, we have asked them for represent the bacteria by using the plasticine (clay). Among the group, only one student had difficulties in representing the spherical shape of the streptococci. This student represented it using a flattened form (2D) similar to the Atlas representation (**Figure 2**). Due to this result, we explained again the streptococci spherical shape to this student by using analogies such as the form of an orange, tennis ball, football and even a door handle. Previous studies have shown the need of using concrete and physical experiences with children, especially those with visual impairments. The main purpose was to make a parallel between the concept and the object, using an appropriate oral approach, helping the student to make comparisons with the environment around. According to the statement of the confused student, the further explanation was helpful.

The presence of students with severe visual impairment in the IBC group (n = 3) was essential to assess the suitability of the font size and colors of the material that were 100% suitable, according to them. Analogously to the literature, we have noticed that is of utmost importance that these students have a variety of materials that provide support to their school activities, such as tactile posters, paintings and materials that allow them to explore tactile, visual, and kinesthetic senses, causing multiple sensations, in addition to information accompanied by the caption in Braille and enlarged letters.

In this work we briefly evaluated the opinion of these students about the Atlas using a questionnaire (**Table 1**) with five questions. All four objective questions had 100% positive response including that one made only for the severe visually impaired students, who have contact with textbooks with bacteria illustrations. Their answers reinforced the didactical profile of the material, at least pointing to the acceptability of it.

The final question (*Do you have any suggestions that might improve the material*?) generated positive and pleasant responses that showed that the students enjoyed participating in these activities. The most important suggestion was *to produce the material in larger quantities and make available to other groups who have blind or visually impaired students*.

After the interview, we have opened for a free chat when they have asked many questions about different topics including other types of bacteria, multiresistant strains current in the media (KPC), among many others, revealing a good timing and opportunity to talk about biotechnology and the potential of these bacteria to be used by men for biotechnological purposes (Clarke, 2013). It is of notice that it is important for them to receive materials that allow approaching other topics and that motivate them to know about it.

According to some authors, the teaching material should be selected according to their focus on the learning process including the purpose such as informing, enhancing the understanding, contextualization or using a new dynamic approach, among others (IBC, 2014). Once the function is defined, it becomes easier to select the appropriate material for the task to be undertaken. It is worth mentioning that the Atlas of the Kingdom Monera could be classified as a didactical material that helps on memorization of bacteria morphology since it may be

Table 1. Objective questions used in the interview with the IBC group after using the ATMK.

Question	Answer		
	Yes	Little	No
Did the Atlas facilitate your understanding about the morphology of bacteria?	6	0	0
Did the Atlas add some information for you?	6	0	0
Did you like the material and would recommend it for a friend to use it?	6	0	0
Are the Atlas representations similar to figures present in textbooks?[a]	3	0	0

[a]This question was made only for the severe visually impaired students, who have access to textbooks with illustrations of bacteria.

used after the theoretical content.

Our results corroborate the literature that suggested that the formation of images and concepts of blind participants takes place through sensory, tactile, auditory and/or olfactory, also related with language experiences of the people involved (Katz, 1989). Visually impaired individuals have a different way of learning, which imply that to build their concepts they need more time to experiment, learn and sequentially organize their experiences and knowledge (Millar, 1991). Although these students have the same condition to learn and build their own concepts universe such as other students, different criteria involving methodology and resources should be used to productively develop and use their teaching and learning skills (Millar, 1976; Heller, 1991, 1993).

Inclusive Education begins to take its first steps and there is still much to grow and develop for attending the public with special needs (Wilson, 2002). Other reports such as Lima & Da Silva (2005) who developed a pen for thick drawing that allows production of creative activities and materials for people who are blind or visually impaired, Souza and Coworkers (2012) that produced a low cost material about Fungi Kingdom, and Cook and Hussey (2007), which described assistive technologies, open a new space for including other professionals and new activities such as the creation of other materials and equipments for attending this public.

4. Final Remarks

Herein, our report about the construction of the ATMK may help in developing proper conditions for teaching microbiology and biotechnology not only for visually impaired students but for all students, with appropriate, accessible and high quality conditions. A content that has methodological basis, which incorporates the experience of teaching, encouraging students with special needs is still absent or restrictive not only in literature (Farrel, 2000; Wilson, 2002) but also in many university training teachers' curricula. Therefore our simple and low cost methodology may help these professionals on attending this public and on planning new inclusive materials.

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