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RESEARCH PAPER

Two-dimensional and three-dimensional models used for teaching Human Evolution in Secondary Schools. Learning proficiency assessment. A Case Study

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Abstract

The evolution of the human species is a topic of extreme importance reported in the "Parâmetros Curriculares Nacionais do Ensino Médio – PCNEM" (National Curriculum Standards of Secondary Education), although it is not often taught as part of basic education. This work presents the results of an experimental work performed with 31 students of a religious high school of State of Rio de Janeiro. Learning proficiency was assessed by using two-dimensional (2D) and three-dimensional (3D) illustration techniques of hominids skulls and a Pongidae for teaching Human Evolution. The teaching-learning process using these methodologies was more effective with the application of three-dimensional (3D) illustration techniques. The group of students that used 3D illustrations were able to observe similarities and differences between the presented taxonomic models, and formulate hypotheses about their palaeobiology more consistently than the students that used 2D models. Results of this work indicate that the use of three-dimensional techniques (3D) provides an excellent support to teaching-learning process in basic education, captivating and stimulating new interests of students during the educational process.

Keywords: Science Education. Human evolution. Didactic resources. 2D/3D Models. Paleobiology. Computer.

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1. Introduction

The evolution of the human species is one of the most important topics of evolutionary theory, because it explains the common ancestry between species due to genetic modifications marked by natural selection, environmental influence, culture and migration (Penny and Poole, 1999; Ayala, 2007). This theme is very relevant, since it tries to explain the wide range of different human characteristics that are distinct from other living beings.

A proper understanding of the emergence and evolution of life in its various forms of demonstrations and demands provides an understanding of the geological and environmental conditions prevailing in the primitive world, allowing to develop educational projects that seek to test hypotheses about the evolution of species, including humans (Brasil, 2000).

In accordance with the PCNEM the approach and learning of these Biology issues is inseparable from the other sciences (Brasil, 2000).

According to the "Orientações Complementares aos Parâmetros Curriculares Nacionais do Ensino Médio" (Complementary Guidelines to the National Curriculum Parameters of High School), students should understand vital processes at different scales of time and become familiar with the basic mechanisms that allowed the evolution of life and of the human being in particular (Brasil, 2002).

The document "Currículo Mínimo" (Minimum Curriculum) of State of Rio de Janeiro, proposes that issues related to human evolution should be taught in high school, during the first grade, from the end of the second quarter and during the entire third quarter (Rio de Janeiro, 2012).

Despite these recommendations, the teaching of this subject has found obstacles related to specific concepts of evolutionary theory (such as adaptation and evolution), school socioeconomic context (such as lack of infrastructure and lack of teachers) and cultural characteristics of students including religious beliefs (Castro and Augusto, 2009; Silva et al., 2009; Pazza et al., 2010; Oliveira and Bizzo, 2011; Oliveira et al., 2011; Roberto and Bonotto, 2012; Vieira and Falcão., 2012).

According to Moura and Silva-Santana (2012), some researches have shown that teachers have Lamarckian conceptions about human evolution and evolutionary theory, which are taught in the third year of high school. According to these authors, the investigated teachers declared that there are in the schools lack of teaching materials and insufficient time for teaching that subjects (Tidon and Vieira, 2009; Mottola, 2012; Moura and Silva-Santana, 2012; Roberto and Bonotto, 2012). Vieira and Falcão (2014) observed that in a religious school the teaching of the evolutionary theory is limited and teachers present the evolution in a context of devaluation of scientific explanations.

Several studies have shown that 3D technology provides more motivating and engaging environment for the practice of educational tasks than the 2D one (Santos et al., 2003; Seabra and Santos, 2004; Toti et al., 2008).

According to Bento and Gonçalves (2011), navigation in a three dimensional environment is easy to handle and so young people do not feel great difficulty in dominating it.

In paleontology, the analysis of 3D models can facilitate the observation of morphological structures of the fossil skeletons improving the educational process (Sutton et al., 2001).

The use of the 3D technique enables the understanding of the spatial structure of the scanned material, allows to analyze more precisely the functioning of the anatomical parts of the organisms (Wilhite, 2003).

This work is the result of a survey that aimed to compare the learning process of the human evolution theme using two different methods: 3D technology and traditional teaching resources based on 2D models, in order to verify which method allowed to obtain better results of learning. It also had the following objectives:

1) To observe and analyze the similarities and differences between the skulls of the following species: *Homo sapiens sapiens*, *Homo sapiens neanderthalensis*, *Homo erectus*, *Australopithecus afarensis* and *Pan troglodytes*.

2) To observe the structures - jaws, sagittal crest, teeth, foramen magnum, prominence of the face, observation of facial features in side view of skull, supraorbital arch and nasal passages and to show differences between the skulls of the mentioned species.

3) To motivate students to formulate hypotheses related to the form of communication, food and human evolution, based on the observation and analysis of the characteristics of anatomical structures.

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3. Material and methods

In a first stage, the employed didactic strategy to achieve mentioned objectives (in the previous section) consisted of three procedures with total duration of 45 minutes:

I. Lecture showing 2D and 3D models of the skulls of the following species: *Homo sapiens sapiens* and *Homo erectus*; *Homo erectus* and *Australopithecus afarensis*; *Australopithecus afarensis* and *Pan troglodytes*; *Homo erectus* and *Homo sapiens neanderthalensis*.

II. Skulls comparison: students observe the differences and similarities between the structures of hominids and a Pongidae.

III. Hypothesizing about differences and similarities of the skulls. It is important in this activity, motivate students to observe and analyze such structures and then propose to them the formulation of hypotheses, questions or doubts.

All the questions or concerns presented by the students were appreciated and considered as explanatory hypotheses and then discussed with the monitor (two graduate students in biological sciences and a PhD student in Science Education and Health). Then students separated into two groups (with 2D and 3D models), answered to a questionnaire for approximately 45 minutes.

Students of the third year of high school, involved in this research, attended an Adventist school, located in a church of the same name. The school has good physical structure, with ventilation (air-conditioned) and lighting classrooms, whiteboards, comfortable desks, modern pedagogical teaching equipment (portable projectors and computers), library, staff room, auditoriums for lectures and meetings with parents, pedagogic coordination and support of a psychologist.

This school offers education from kindergarten to the pre-university. The curriculum of this school for high school is comprised of the regular disciplines (Portuguese, Mathematics, Biology, Physics, Chemistry, History, Geography, Literature, English and Spanish). The curriculum also includes the Religion study.

The political pedagogical project of this school includes teaching of all aspects of the evolutionary theory (basic concepts, evidence of evolution, evolutionary theories of Lamarck and Darwin, evolutionary mechanisms and modern aspects of genetics related to evolution. However, teachers are oriented to teach these issues in articulation with the Christian precepts.

It is important to note that this research was approved by the school administration, by the teaching college of Biology and by the Comissão Nacional de Ética em Pesquisa-CONEP (National Research Ethics Commission of the UFRJ, documented by the number 052907/2013).

The activities took place in the "Museu de Geodiversidade" (Museum of Geodiversity) and in the "Centro de Estudos de Mudanças Ambientais" (CEMA; Research Centre of Environmental Changes), both in the "Instituto de Geociências" (Geosciences Institute), of "Centro de Ciências da Matemática e da Natureza" (Sciences Center of Mathematical and Nature) of UFRJ.

To perform the activity with the 2D teaching resource, the module of the "Museu de Geodiversidade" (Geodiversity Museum) with the exhibition of Brazilian dinosaurs was chosen. This module provides images via a pen drive and a television equipment.

To work with the 3D educational resource, the space chosen was the CEMA, using a projector, laptop and the website http://www.nhm.ac.uk/nature-online/life/ human-origins / modern-human-evolution/3d (Fig. 1) of the Natural History Museum in London, England. This page allows the observation and the evaluation of the similarities and differences of the structures of the skulls of hominids and a Pongidae.

In the activity using the 2D didactic recourses, images taken from the page http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls/ were used, treated and exported with extension *.jpg (Figs. 2-6). On this website page, skulls can be moved and handled horizontally.

The 2D images were made from 3D models, taken from this site and processed in Adobe Photoshop. In this way, students were able to use the same skulls, with a difference of three-dimensional and two-dimensional view.

Thirty-one students participated in this study in the refereed school: a group of 15 students made the proposal with the 3D teaching tool, and the other group of 16 students, conducted the activity with 2D teaching resource.

The members of each team were randomly chosen. The two students' groups had no contact. The activity lasted approximately 1 hour and 30 minutes.

Students wore coats used clipboards and pens to make records of what they observed in the museum.

The approach of the content was carried out with 3 monitors that addressed topics related to evolutionary theory. Students analyzed the similarities and differences between each skull of the studied species.

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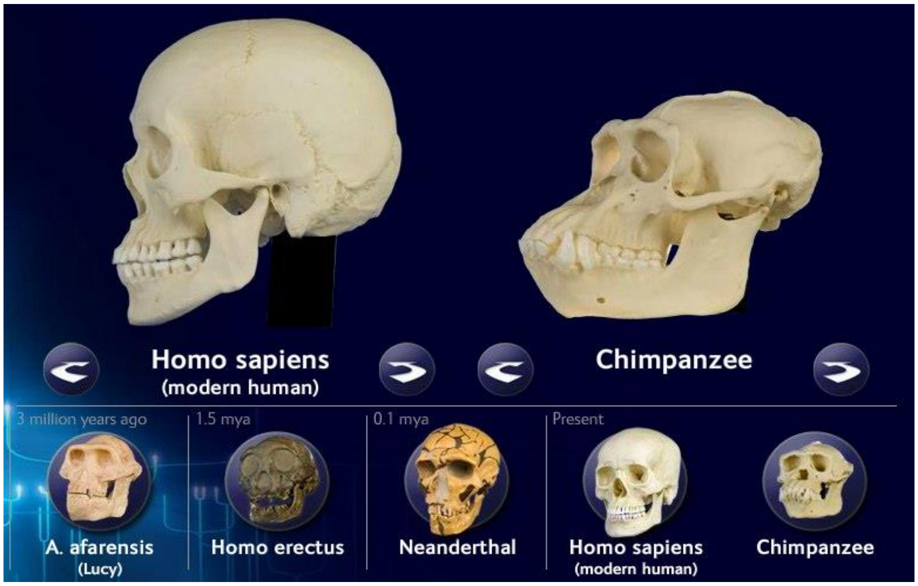

Fig. 1. 3D models giving a sense of visual immersion. Image taken from http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls

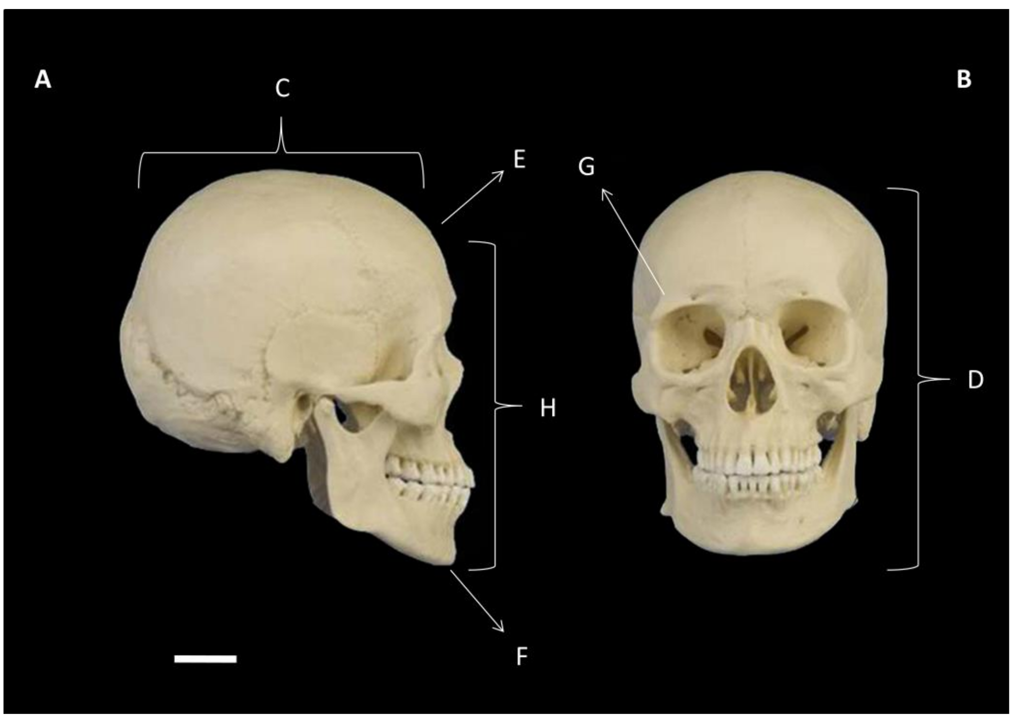

Fig. 2. Side (A) and front (B) view of the skull of *Homo sapiens sapiens*. C: Not elongated skull, D: High braincase, E: High frontal region, F: Presence of chin (Mental Protuberance), G: Supraciliary high and not prominent arcade and H: Sinuosity face no prominent. Scale Bar: 5 cm. Modified from <http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls>.

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Data collection was performed by means of an anonymous individual questionnaire. This tool contained open questions related to the differences and similarities of hominid skulls (*Homo sapiens sapiens*, *Homo erectus*, *Homo sapiens neanderthalensis*, *Australopithecus afarensis*) and a *Pan troglodytes*. To analyze the perceptions and the learning process of students about human evolution, the concept of social representations of Serge Moscovici (Santos and Dias, 2015) was used. This concept, based on the integration of interpretations and answers, allows to evaluate what are the formulations that form a 'concept group' about a given information (Jodelet, 1990; Sêga, 2000).

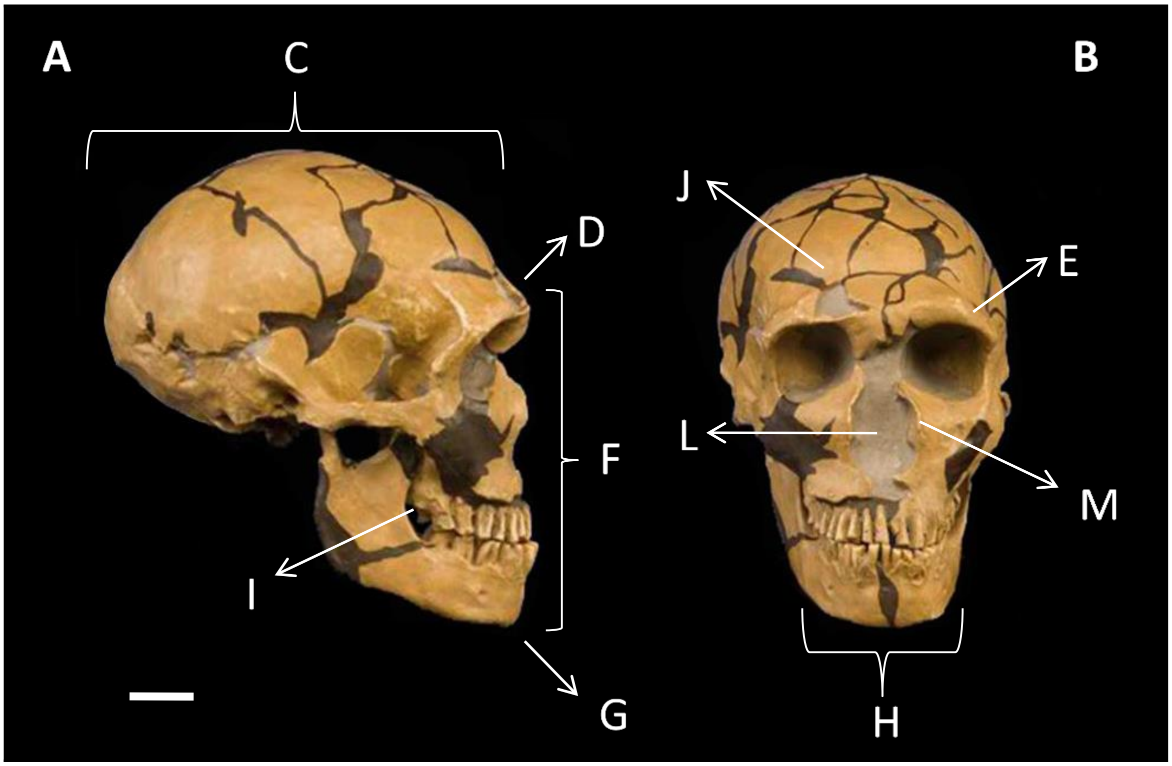

Fig. 3. Side (A) and front (B) view of the skull of *Homo sapiens neanderthalensis*. C: Skull large and elongated backward, D, E: Prominent supraorbital arcade, F: Sinuous face and low prominent, G, H, Absence of Mental Protuberance, I: Space between the curvature of the jaw with the last molars, J: Retreated frontal region, L: Broad nasal aperture and M: bony protuberances on the sides of the nasal aperture. Scale Bar 5 cm. Modified from <http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls>.

Students of each team create a network of relationships with each other aiming to design the best structure of new knowledge, which is influenced by the social relashionships and cognitive functioning organization of the team members (Sêga, 2000).

In this work, the social representations are used to analyze which were the visions, values and effects built by students after the activity about human evolution teaching. Such representations were analyzed by the technique of the Collective Subject Discourse (CSD) developed by Lefèvre and Lefèvre (2003).

This technique consists of write a single speech in the first person singular, through various statements (reporting their assumptions and opinions) collected in a specific team and thus it can be used as a case study. It is a technique that

This technique is applied in opinion polls and and is used to review answers given to open questions, grouping the statements with similar sense of synthetic discourses written in the first person.

The CSD methodology consists of analyzing statements and other verbal materials by removing the central ideas from Expressions Key (EC).

From the central/anchors and correspondents EC ideas, one or more synthetic discourses of the collective subject are constructed (Godim and Fischer, 2009).

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allows the obtainment of quantitative data, since it allows to register the number of individuals that share the same central idea. It also provides qualitative data which can be converted into numerical data. In this way, the CSD provides qualitative information which may have statistical applicability (Diniz et al., 2011).

4. Results

Tables 1-3 synthesize the student responses given to three central ideas (CSD1-CSD3) related to the following questions: 1) "What are the differences of sinuous in the lateral profile of each skull?"; 2) "What kind of influence has developed this difference?"; 3) Do you think that *Homo sapiens neanderthalensis* could speak? Explain your answer.

The answers to those questions is based on the analysis of 2D or 3D educational resources that were provided to each working teams. These issues were selected because they are the most relevant in evaluating the development of hypotheses about human evolution in relation to anatomy, influence of the environment and culture (eg: communication). Thus they provide a greater chance of learning evaluation and formulation of hypothesis about human evolution.

Tables 1-3 record the answers to three key ideas (CSD1-CSD3) and also summarize the discourse synthesis built by students from their answers. The number of concordant answers to each question was included in that tables.

3.1 Results presented in Table 1

In CSD1 and CSD2 of Table 1, the students observed and evaluated the similarities and differences, between the analysed skulls. In CSD3 of Table 1, students observed and analyzed the similarities between the skulls of *H. sapiens* and *H. sapiens neanderthalensis* and also distinguished the differences between the skulls of *H. erectus* and *H. sapiens neaderthalensis*.

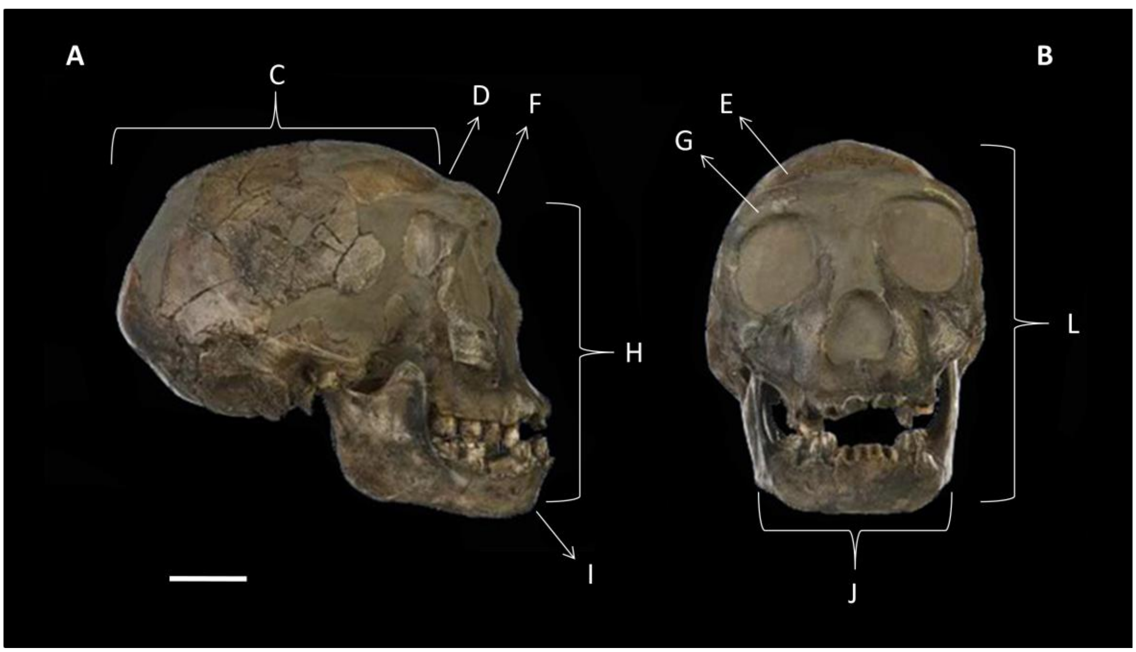

Fig. 4. Side (A) and front (B) view of the skull of *Homo erectus*. C: Elongated skull backwards; D, E: Retreated frontal region; F, G: Prominent supraorbital arcade; H: Considerably prominent face; I, J: Absence of mental protuberance and; L: Low braincase. Scale Bar 5 cm. Modified from <http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls>.

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Tab. 1: Answers to the query: "What are the differences of sinuous in lateral profile of each skull?". The number and percentage of answers included at the end of each response indicates the absolute and relative abundance of students who agreed with this response.

Central Idea	3D	2D
CSD1 - *Homo sapiens neanderthalensis* is similar to *Homo sapiens sapiens.*	"The face of the skull of Neanderthal (...) is developed and presents sinuous (...) viewed from side. (...). They are similar to the face and skull (...) of *Homo sapiens sapiens* (...) (6), 40%	"Observing the side of *H. sapiens neanderthalensis* skull (...): its size is normal, his face is sinuous (...) and his jaw is elongated (...), similar to our". (4), 19%.
CSD2 - *Homo sapiens neanderthalensis* is different from *Homo erectus.*	"The skull of Homo erectus has his face and (...) jaw much more prominent and less sinuous (...). The Neanderthal skull has a slightly prominent jaw and much larger skull". (14), 93%	"Observing the side of both skulls (...), The Neanderthal man has skull with side features (...), your face is more sinuous, with finer details. The skull of *H. erectus* is flattened, small and round". (6), 38%
CSD3 - *Homo sapiens neanderthalensis* is different from *Homo erectus* and similar to Homo sapiens sapiens.	"The skull of Neanderthals is different from *H. erectus* and much more similar and (...) almost equal to our skull (...)". (5), 33%	"The Neanderthal is different than *H. erectus*, but has a skull much more similar to our one". (1), 6%

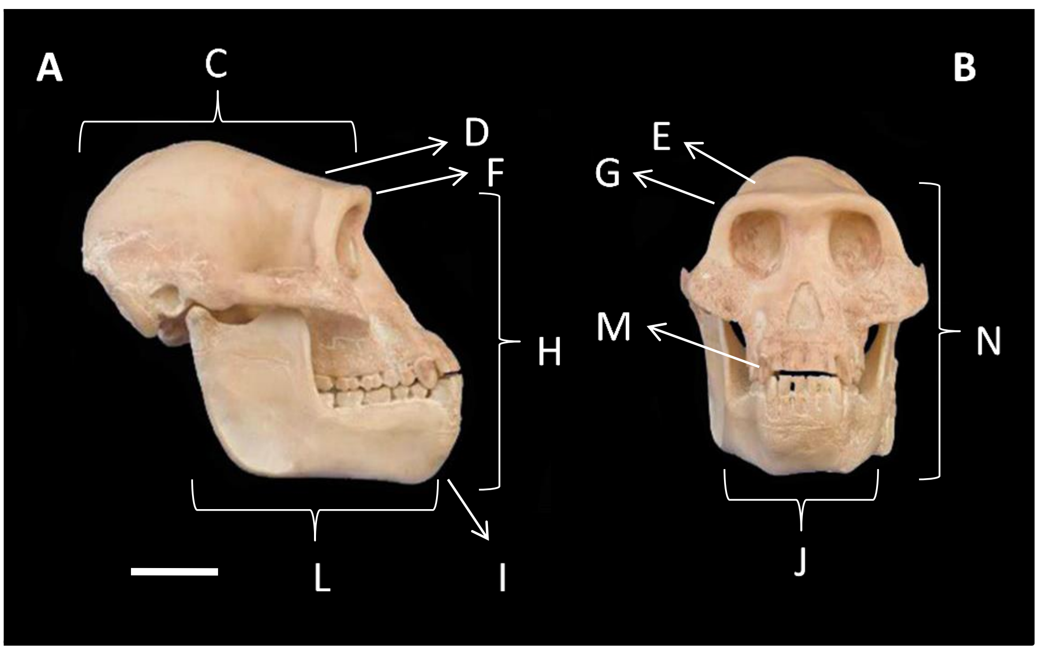

Fig. 5. Side (A) and front (B) view of the skull of *Australopithecus afarensis*. C: Elongated skull backwards; D, E: Retreated frontal region; F, G: Prominent supraorbital arcade; H: Significantly prominent face and presence of canines; I, J: Absence of mental protuberance; L: High and long length jaw; M: Presence of canines and; N: low braincase. Scale Bar 5 cm. Modified from <http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls>.

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3.2 Results presented in Table 2

Table 2 records the answers to the question "What kind of influence has developed this difference?". In both teaching resources, students perceived more intrinsic influences (increasing of cranium) in relation to extrinsic influences (food and environment). In CSD1 (Tab. 2), students considered that the difference between the faces of *H. erectus* and *H. sapiens neanderthalensis* skulls was caused by the volume of the cranium. In CSD2 (Tab. 2), students considered that this influence was due to external factors (environmental and food). In CSD3 (Tab. 2), students considered that this influence should have been caused by both internal factors, but also by external factors, such as environment, food and skull size. This last discourse only was made by students who developed the activity with the 3D educational resource.

3.3 Results presented in Table 3

Table 3 shows the responses to the question: "Do you think that *Homo sapiens neanderthalensis* could talk? Explain your answer". This table shows that the students answered affirmatively to the hypothesis that *H. sapiens neanderthalensis* could speak.

In CSD1 (Tab. 3), all students, with the 3D educational resource, shared the observation of the similarity of *H. sapiens neanderthalensis* and the *H. sapiens sapiens* skulls. In CSD 2 (Tab. 3), most students using the 2D teaching resource, supported the hypothesis what *H. sapiens neanderthalensis* could not speak since the tongue muscle was little evolved. But they shared the idea that the evolution could determine structural improvements arguing that "Yes, because he has the tongue muscle little evolved". This suggests that the 2D teaching resource may have contributed to this misunderstanding, due to the absence of a more suitable analysis of this evolutionary aspect.

In CSD3 (Tab. 3), few students considered the similarity between *H. sapiens neanderthalensis* and H. *sapiens sapiens* skull.

Tab. 2. Answers to the query: "What kind of influences has developed these differences?". The number and percentage indicated at the end of each answer indicates the absolute and relative abundance of students who agreed with the given response.

Central Idea	3D	2D
CSD 1. intrinsic	"This difference is due to the size of the skull of the Neanderthal, which had the largest brain (...), having greater intelligence. He could probably cook which could helped him in cold environments". (15), 100%	"*H. sapiens neanderthalensis* was cleverer". (6), 38%
CSD2. extrinsic	"This difference is due to food and the environment (...) where *Homo erectus* is more adapted to eat hard food. The Neanderthal lives in colder environments and eat softer food". (13) 86%	"This difference is due to the region where they live and what they eat". (4), 25%
CSD3. intrinsic and extrinsic	(13), 86%	(0), 0%

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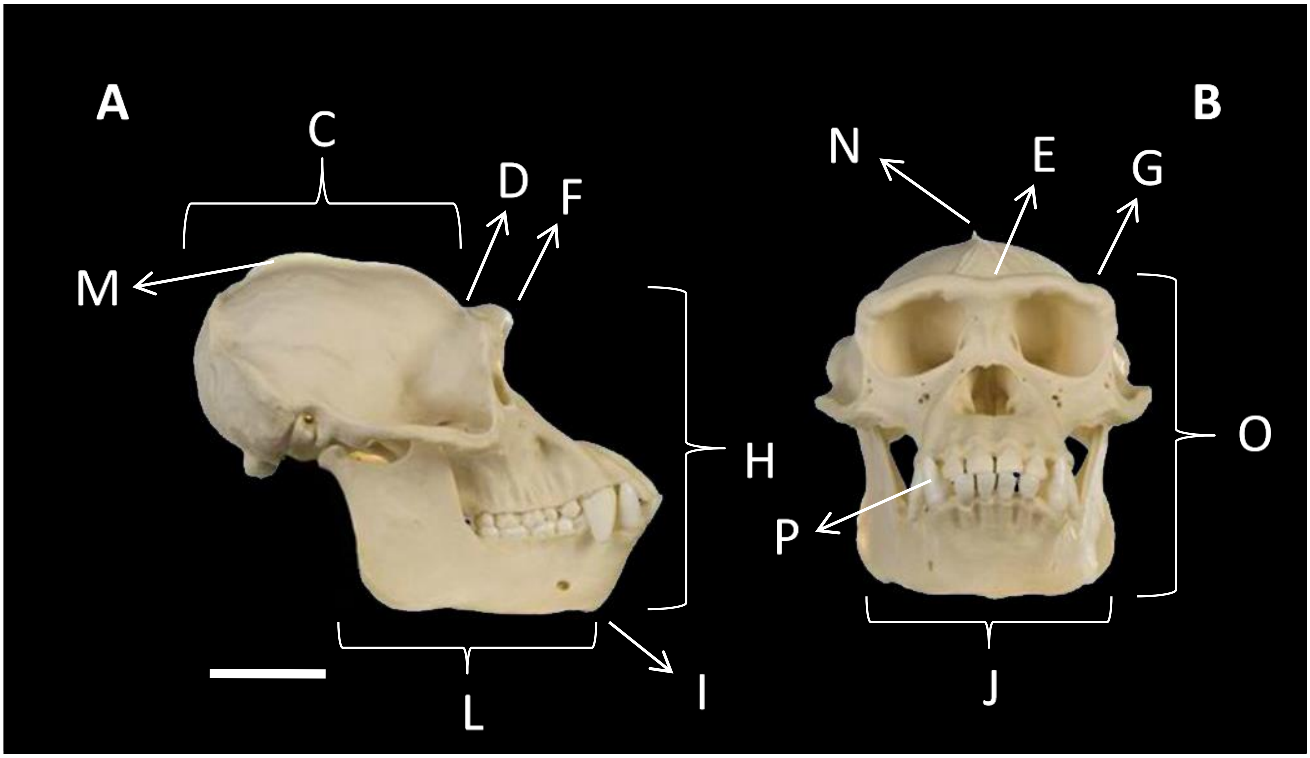

Fig. 6. Side (A) and front (B) view of the skull of *Pan troglotydis*. C: Elongated skull backwards; D, E: Retreated frontal region; F, G: Prominent supraorbital arcade; H: face very prominent with the presence of canines; I, J: Absence of mental protuberance; L: Prominent bit and long jaw; M, N: Presence of sagittal crest; O: Low braincase and, P: Presence of large canines. Scale Bar 5 cm. Modified from <http://www.nhm.ac.uk/nature-online/life/human-origins/modern-human-evolution/3d-hominid-skulls>.

3.4 Results presented in Table 4

The Table 4 summarizes the hypotheses built by students to the question "Do you think that *Homo sapiens neanderthalensis* could talk? Explain your answer". This table shows that the number of hypotheses formulated by students involved in the activity with the 3D teaching resource was higher when compared to the activity with 2D teaching resource. The first group also presented a greater diversity of hypotheses.

In the 3D activity, the assumptions made by the students were more related to similarities between the skulls, the shape of the skull, the brain dimension and the ability to think. Whereas in the activity with 2D teaching tool, students formulated hypotheses more related to the muscles, the brain dimension, the ability to think, the jaw similarity and the shape of the jaw. Results presented in Table 4 evidence that there was a difference both in the quality and quantity of hypotheses formulated by both groups.

5. Discussion

The results presented in Tables 1 and 2, evidence that for all CSD, the students who analyzed 3D educational resource responded more appropriately than students that used the 2D teaching resource.

In these tables, most of the students who analyzed the 3D teaching resource apprehended the differences between the analyzed skulls, due to the possibility of handling the 3D model of the skull. In the case of the group with 2D teaching resource, only a few students were able to see the differences between the analyzed skulls.

The students with the 3D teaching resource were able to associate and link several analysis perspectives. This result is a consequence of a better observation and perception of the studied structures. So the students were able to articulate and formulate more plausible hypotheses.

In Table 3, we note that all students in both activities, realized that the skull of *H. sapiens neanderthalensis* was similar to that of *H. sapiens sapiens*.

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However, in the activity with 2D teaching resource, they included the argument that "the language was less evolved". Thus they presented a misconception: “as he was an older hominid, he had a less developed language”. This view may have been attributed to the fact that hominids had less developed features. These results suggests that the 2D didactic recourse did not allow a correct analysis due to the characteristics of the study material. Note that the responses of the 2D team do not total 100%.

In Table 4, it is noted that students with 3D teaching recourse were able to formulate more hypotheses than the students with 2D teaching resource. These results suggest that the 3D models provide a more accurate perception, a better analysis of structures which allowed improved hypothesizing.

Tab. 3. Answers to the query: “Do you think that *Homo sapiens neanderthalensis* could talk? Explain your answer”. The number and percentage included at the end of each response indicates the absolute and relative abundance of students who agreed with this response.

Central Idea	3D	2D
CSD1. Yes, they had similar braincase.	“Yes, they have the large braincase like ours (...). Very similar to ours. Thus the brain was greater”. (15) 100%	0(0%)
CSD2. Yes, because the tongue muscle was little evolved.	0 (0%)	“Yes, because he has the tongue muscle little evolved”. (10) 62%
CSD3. Yes, they had the skull similar to ours.	0 (0%)	“Yes, they have similar mandible, jaw and brain to *H. sapiens*”. (3) 19%

Tab. 4. Hypotheses built by students to the question “Do you think that *Homo sapiens neanderthalensis* could talk? Explain your answer”. The number and percentage included at the end of each response indicates the absolute and relative abundance of students who agreed with this response.

Hypotheses	3D	2D
Because of the shape of the braincase.	(10) 66%	0
By having a larger brain capacity to think.	(4) 26%	0
By owning a similar skull to *Homo sapiens sapiens*.	(6) 40%	0
Because they have developed muscle for this.	0	(4) 25%
Because they have larger brains, ability to think.	0	(1) 6%
By owning a similar jaw to Homo sapiens sapiens.	0	(1) 6%
By the form of jaw.	0	(2) 12%
Total	**20**	**8**

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The CSD analysis was a usefull thecnique to evaluate which of teaching resources (2D and 3D) have generated greater motivation and learning opportunity. According to Cavicchia (2010), motivation also improve the affective relatioshionships and hence the cognitive process.

The CSD analysis showed that students who participated in the activity with 3D teaching resource had better results, formulated more hypotheses and shared more than a discourse. They also were able to build a new knowledge without incorrect concepts about human evolution through intense interaction with the team members and careful examination of the fossils into three-dimensional models.

Students who participated in the activity with 2D teaching resource were able to make observations, formulate hypotheses and construct new knowledge through the interaction between students and monitors, but some concepts about human evolution remained equivocal. "Yes, because he had the tongue muscle little evolved" – this sentence summarizes the responses given by most students involved in the activity with the 2D teaching resource.

According to Vygotsky (1987), when students continue with misconceptions, that is, when the signs are interpreted wrongly, we can deduce that the interaction between the students and professor was not enough for the formation and construction of new knowledge. This small interaction may have influenced the formation of incorrect concepts.

For Gagné (1980), behavioral change is always persistent when the new knowledge is inserted and the individual interacts with it, showing satisfaction and acceptance. For this author, the student reacts to stimulation and motivation, changing their behavior.

According to Comenius (1999), when there are the interaction of more than one sense, for example, viewing and handling (in this case, the virtual handling) the acquisition of knowledge knowledge is improved. In the case of the students who use the 2D models, the misconceptions continued which indicate that the motivation was not enough and the interaction between the students and the didactic recourse were not adequate.

Thus, students of both activities, somehow interacted with each other, interpreting signs, forming and building concepts based on these signs. In the activity with 3D educational models where student formulated questions and doubts, the group interacted much more, answering to such questions and doubts. That is, social interaction helped in the construction and acquisition of new knowledge.

For Vygotsky (1987) the signs (in this case, the new knowledge) are mediated by the relationships, in which all individuals are building their own concepts, and so these are influenced by the social interactions.

The student's behavior in the activity using the 3D teaching recourse revealed that despite some emerging questions or conflicts between science and religion, the students learned and argue coherently about the scientific thinking on human evolution. In the 2D activity, some students were inattentive or uninterested about the subject.

The quality of the answers expressed by the students involved in the activity using the 3D teaching recourse are linked with their enthusiasm and understanding the content. According to Martins et al. (2005), the interest by the scientific content is facilitated by the efficiency of the teaching resource and its effectiveness as a learning motivation tool. The emotional and motivational processes are essential for an activity that is full of signs, in which the student has the opportunity to observe, analyze and formulate their hypotheses (Flavell et al., 1999; Moreira, 1999; Sternberg 2000; Uller, 2007).

The use of an effective teaching tool can help the students to understand the new concepts that are being taught. So the choice of the resource and convenient planning of the activity is of paramount importance.

According to Bento and Gonçalves (2011), the use of 3D models is more motivating than the 2D images. Teaching resources with 3D models provide a better analysis of biological structures than 2D models. Thus the use of 3D models can be important as a didactic recourse for the paleontology teaching.

6. Conclusion

The 3D teaching resource motivated much more the students and helped them to interact, increasing their social, emotional and cognitive relationships. According to the results of this work, the 3D teaching tool allowed for greater ease of observation, perception, comparison and analysis of the anatomical structures of the skull in relation to 2D teaching resource.

This research evidences the importance of the quality of educational teaching resources. They can facilitate the process of teaching-learning.

The 3D teaching tool used in this work, is easily accessible, and promotes more interaction and better learning for teaching subjects related to human evolution than 2D pictures.

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