BOTANY IN SECONDARY EDUCATION: STUDENTS' VIEWS ON NATIVE FLORA AND TECHNOLOGY

A botânica na educação básica: o olhar dos estudantes sobre a flora nativa e as tecnologias da informação e comunicação

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Abstract

This research aimed to assess students' perceptions regarding the study of the Brazilian flora and the use of technology in the learning of botany. It was mainly motivated by the necessity for improving the teaching of botany in Brazil, in an attempt to make the learning more dynamic and contextualized, as well as to motivate both students and teachers. The methodology encompassed the application of a questionnaire, a botanical game, and interviews. Most students were found to have a limited understanding about the Brazilian flora and its history. In addition, the students pointed out that the inclusion of technology would be beneficial for their learning process, and 'perceived usefulness' was observed to be a determining factor of their opinions. During the game, they proved to be interested and involved. The interviews revealed their necessity to know more about the native flora in order to preserve it.

Keywords: botany learning; Brazilian flora; information and communication technology; secondary education; game activities.

Resumo

Esse trabalho buscou conhecer as percepções de estudantes sobre o estudo da flora brasileira e o uso da tecnologia na aprendizagem de botânica. A pesquisa foi impulsionada, principalmente, pela necessidade de refletirmos sobre o ensino de botânica no Brasil, com vistas a dinamizar e a contextualizar a aprendizagem, bem como motivar estudantes e professores. A metodologia consistiu na aplicação de um questionário, um jogo botânico e entrevistas. A maioria dos educandos demonstrou ter conhecimentos limitados sobre a flora brasileira e sua história. Além disso, os estudantes apontaram que a inclusão da tecnologia pode os auxiliar no estudo do conteúdo, sendo o fator 'utilidade percebida', determinante em suas opiniões. Durante o jogo, os educandos mostraram-se interessados e envolvidos. Nas entrevistas, eles destacaram a necessidade de conhecerem mais sobre a flora nativa para aprenderem como preservá-la.

Palavras-chave: aprendizagem de botânica; flora brasileira; tecnologias da informação e comunicação; educação básica; atividades lúdicas.

Introduction

According to the Brazilian Catalogue of Plants and Fungi, around 41,000 species of plants have been estimated in Brazil, 46.2% of which are endemic (Forzza et al., 2010; Donaldson, 2013). This catalogue contains most currently knowledge regarding the flora diversity of Brazil since the publication of *Flora brasiliensis* (1840-1906), the largest botanical effort on a neotropical region, describing no less than 22,767 species of terrestrial plants (Forzza et al., 2010).

Brazil is recognised as megadiverse in terms of flora and fauna. It has unique ecosystems, most of which are not to be found anywhere else. It contains the world's largest extension of tropical forests concentrated in the Amazon region. A total number of 32,364 species of vascular plants occur in the Brazilian territory, which is the world's largest distribution (Forzza et al., 2010).

These data emphasise the significance of the Brazilian flora to the entire world and the necessity for the government, school managers and educators to focus on the teaching of botany in the country. Students need to be made aware of the richness of the native species, their potential in the treatment of diseases, and the obstacles encountered over the years in protecting the Brazilian nature.

The Brazilian educational official guidelines indicate that students should be educated in order to participate in the contemporary debates involving the biodiversity of Brazil and its impact on the global population. The guidelines also emphasize that the teaching of biology should keep some level of connection to the everyday life of the Brazilian students (Seb, 2006). However, there is still much to be done before a contextualised botanical education in the secondary level is accomplished.

It is evident that the traditional methods of teaching biology as a non-contextualized knowledge, ignoring experiences and references to real practices must be reversed. Instead, this science needs to be presented as a “way” of broadening the students' concepts of the reality through which biological phenomena must be perceived and interpreted, and used as a tool to steer decisions and interventions (Semtec, 2002).

Researchers reveal that one of the major problems that the teaching of botany face is the gap between school education and the everyday routines of most students. Usually, lessons learnt at school are useful only for students to answer their exams, but they do not know how to apply that knowledge to preserve and appreciate plants, for example (Figueiredo et al., 2012; Freitas et al., 2012; Silva & Ghilardi-Lopes, 2014; Matos et al., 2015). In addition to that, botany education is most often disconnected from Brazilian history and other scientific knowledge. Another important feature is the excessive memory work involved (Santos, 2006; Freitas et al., 2012).

In such a context, it is required that educators rethink their approaches to teach botany and employ methods which will facilitate an active and meaningful learning. Many educational strategies can be applied in this sense, such as projects, games, and the use of ICT (Information and Communication Technology) which stimulate creativity and teamwork (Semtec, 2002; Seb, 2006). ICT is valued for the possibilities to motivate students for the learning of science, because the classroom can be transformed into an attractive and comfortable environment (Ruppenthal et al., 2011).

Currently, several researches have been presented on the use of ICT in biology teaching. Thomas & Fellowes (2016) explored the influence of mobile technology on the bird identification skills of UK graduate students. In botany teaching, Levesley et al. (2014) referred to an online teaching tool called ‘TREE’ that enables access to conferences and facilitates the downloading of educational botanical materials. The authors emphasised that this resource was effective to involve

both the teachers and students in the teaching of plant science. Therefore, the aim of this study was to assess students' perceptions regarding the study of the Brazilian flora and the use of technology in the learning of botany.

Methodology

Participants

This survey involved 157 students enrolled in the first, second or third year of secondary education, between 15 and 17 years old. Of the total, 61% were girls and 39% were boys. They were enrolled in four public schools located at the city of Itaperuna, located some 300 km north of Rio de Janeiro.

Questionnaire applied

A two-section questionnaire was used in this research (Appendix 1). The first section contained three open-ended questions (items 1 to 3) that aimed to assess the students' prior knowledge regarding Brazilian flora: species name, predominant biome in the region that they live in, and historical episodes.

The second section of the questionnaire included twelve multiple choice questions, each of them characterized by an affirmative and a five-point Likert scale for the response, as in: 1 - Strongly disagree; 2 - Disagree; 3 - No opinion; 4 - Agree and 5 - Totally agree. The first five questions of this section (items 4 to 8) were adapted from Tuan et al. (2005). These authors developed and validated a questionnaire to assess students' motivation for the learning of science. This questionnaire explores six motivational factors: students' self-efficacy beliefs; their active learning strategies; the value they place on science learning; their performance goals; achievement goals, and the learning environment stimulation. In our research, we adapted only one of these questionnaire factors, viz., the students' value for the learning of botany. According to Tuan et al. (2005, p. 643):

> [...] the value of science learning is to let students acquire problem-solving competency, experience the inquiry activity, stimulate their own thinking, and find the relevance of science with daily life. If they can perceive these important values, they will be motivated to learn science.

The remaining seven questions (items 9 to 15) were adapted from Usoro & Echeng (2015) with the aim to evaluate students' acceptance of including technology in the learning of botany. The factors that we investigated were: the students' perceived ease of use of ICT for academic purposes (item 9); the facilitating conditions for its use (item 10); the students' perceived usefulness of ICT for the learning of botany (items 11 and 12); their motivation to use technology for the learning of botany (item 13); their academic performance expectancy by using ICT in the learning process (item 14), and finally, their behaviour intention for using ICT (item 15).

The questionnaire was applied to groups of circa 20 students and was made available online on tablet PCs. It was pretested with one 20-student group. The students were advised that their participation in the survey was optional and that their personal data would not be revealed. The application of the questionnaire and the other activities of this research occurred in the multimedia learning laboratory of the Fluminense Federal Institute of Education, Science, and Technology located at the city of Itaperuna, Brazil. The students' perceptions about this environment were previously assessed by our group of study. We found that the students considered the laboratory to be relevant for learning, authentic, challenging, and useful, with fun and easy-to-use resources. They also pointed out that it provides opportunities for reflection about their own learning (Cruz et al., 2017).

Botanical game

After the application of the questionnaire, the students were invited to play a game in which they were asked to identify a few native plants with the help of illustrations retrieved from historical works. The images had been carefully selected based on two main objectives: to draw the students closer to the history of science and to present important researches of the Brazilian botany history, such as *Flora brasiliensis*, *Historia Naturalis Brasiliae*, and *Historia Naturalis Palmarum*. In Appendix 2 we present a list of the common and systematic plant names, and also the references of the illustrations used in the botanical game.

The students were divided into groups of five to play the game. The images were made available on tablet PCs and the groups were invited to identify each plant in about five minutes. The game allowed the students to freely access three clues for the identification of each plant. The number of clues accessed per group was accounted, in order to analyze if the groups that accessed more clues correctly identified more plants.

The clues were about: the species' pharmacological potential, morphology, geographical distribution, and cultivation methods; their usage in culinary, cosmetic, and construction; their history in Brazil and connection with the indigenous culture, traditional medicine, and folklore. The clues were compiled after consulting several bibliographic sources such as Lorenzi & Matos (2008), Martins (2009), Rueda et al. (2010), Kury (2013), Cria (2017), and Jbrj (2017) to create a game activity that comprises relevant information regarding the subject. Examples of these clues are those used for the pineapple (*Ananas comosus* (L.) Merril):

(1) It is a typical species from the Atlantic Rainforest that is considered a symbol of the tropical regions;
(2) Since the beginning of the 16th century the fruit was incorporated into overseas cuisine, because of its therapeutic properties. It was called the “king of the fruits”;
(3) The species is widely cultivated in Brazil for the production of fruits - with acidic taste - that can be consumed as juices, sweets, jellies, among others.

Students' interviews and results' analysis

After the game, a few students were briefly interviewed with only one question. We aimed to evaluate explanatory arguments used by them to characterize the learning of Brazilian flora and its history. The results of the multiple choice section of the questionnaire were subjected to Cronbach's alpha analysis and Spearman's correlation using the IBM SPSS Statistics® software, version 20.

Coefficient alpha consists in a measure of the internal consistency of a scale. This coefficient is a direct function of both the number of items and their magnitude of intercorrelation. Spearman's correlation was chosen after the data normality test which indicated that the variables did not follow a normal distribution. For the Cronbach's test, values above 0.700 were established as satisfactory. For the Spearman's correlation, coefficients less than 0.400 were considered of low magnitude; coefficients greater than or equal to 0.400 and less than 0.500 were considered of moderate magnitude, and values greater than or equal to 0.500 were established as correlations of strong magnitude (Spector, 1992; Scattolin et al., 2007).

Results and discussion

In the open-ended section of the questionnaire, 90 out of 157 students answered that they were able to give at least one example of a plant from the Brazilian flora (Figure 1). Seventeen native species were mentioned, with Brazilwood (*Caesalpinia echinata* Lam.) at the top with 39 citations, followed by species of Ipe (*Handroanthus* sp.). In this question, the students erroneously pointed

out 12 exotic species, *i.e.*, plant species that have been introduced to an area from outside its native range, either purposefully or accidentally. From the analysis of question two, it becomes evident that most of the students do not know the name of the predominant biome in the region that they live in. Only 62 of them answered this question and only 48 were able to correctly name the biome (Atlantic Rainforest).

A similar trend was found in question three (Table 1). Only 26 students were able to mention some episode regarding the history of the Brazilian flora. In twenty two of the questionnaires, historical episodes regarding 'extinction', 'deforestation', 'exploitation', 'devastation', 'degradation' were mentioned, and eleven made reference to the exploitation of Brazilwood, the species most cited in question one. Therefore, from the answers to questions one to three it is clear that the students' knowledge regarding the Brazilian flora is poor and they have a limited understanding of its history.

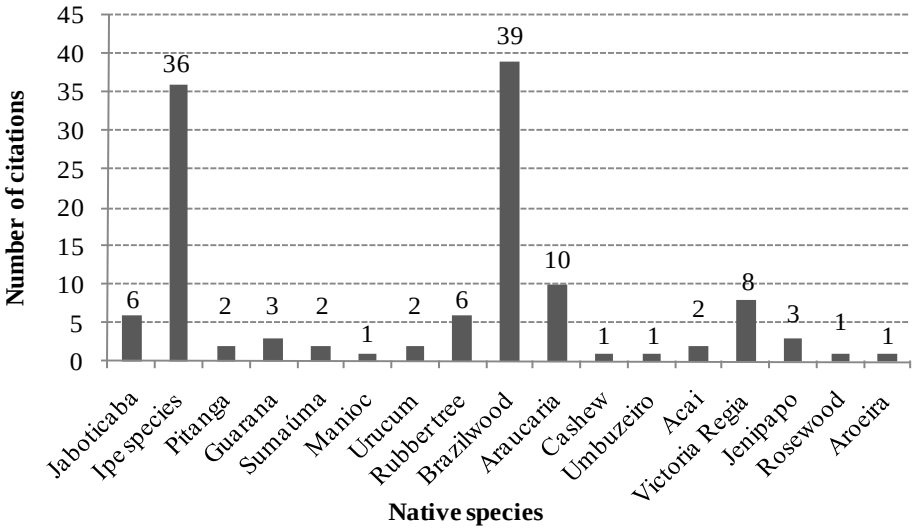

Figure 1 - Native species identified by 90 students who answered to question one of the questionnaire.

Scherer et al. (2015) evaluated the knowledge of 175 Brazilian graduate students about the native and exotic biodiversity. These authors concluded that the students' knowledge regarding biodiversity in general and particularly about the native flora, was scarce. They argued that the knowledge regarding Brazilian biodiversity had been lost over the years and the current schools do not give the proper value to a broader understanding of native fauna and flora.

Textbooks currently available for Brazilian secondary students reinforce this perception regarding the native flora (Sales & Landim, 2009; Freitas et al., 2012; Bezerra & Suess, 2013). Our group of study previously demonstrated that most biology textbooks recommended by Brazilian official guidelines give only a few mentions regarding the native species, which are not often identified as being part of the Brazilian flora. Poor historical information about the subject is provided, and episodes such as desertification, deforestation, forest burning, are highlighted (Cruz & Luna, 2017). Therefore, if teachers only use these educational resources, the learning process will not encourage the students to understand more about the native flora.

The average value of questions four to fifteen ranged from 3.013 to 4.287 (Table 2). It indicated that most of the students concurred with the statements. The Cronbach's alpha for this section of the questionnaire was 0.781, demonstrating the internal consistency of the questionnaire. Table 2 reveals that the item ten exerted the lowest influence on the Cronbach's coefficient; therefore, if it is excluded, the alpha value would remain close to the real one. None of the multiple choice questions, if suppressed, would increase the coefficient value, so all of them are considered significant for the internal consistency.

The analysis of Table 3 indicated two significant correlations between the factors evaluated in the multiple choice section of the questionnaire. The highest correlation (0.703) was found between the two following factors: (1) students' motivation and (2) perceived usefulness of technology for the learning of botany. A second high correlation (0.513) was found between the two following factors: (1) academic performance expectancy by using technology in the learning process and (2) perceived usefulness of technology for the learning of botany.

According to Roca & Gagné (2008, p. 1585-1586), "[...] users' acceptance is the most important determinant of continuance intentions when using any technology". These and other researchers have been investigating the factors which determine the use and acceptance of technology by students and workers (Venkatesh & Davis, 2000; Roca et al., 2006; Usoro & Echeng, 2015). Several factors have been identified, such as perceived ease of use, perceived usefulness, motivation to use, performance expectancy, perceived quality, and cognitive absorption.

Table 1 - Transcript of the responses from 26 students who answered to question three of the questionnaire.

1	The letter in which Pero Vaz describes the characteristics of urucum
2	The extraction of Brazilwood by the Portuguese.
3	After the Portuguese landed in Brazil, the Brazilian flora underwent several modifications, one of which was the exploration of Brazilwood
4	During colonisation, natural resources like wood (Brazilwood) were extracted.
5	From the time the Portuguese arrived in Brazil, the Brazilian flora has faced difficulties, one such example being the deforestation of the Amazon Rainforest.
6	Deforestation occurred with the arrival of the Portuguese and deforestation has now taken place to facilitate industrialisation.
7	From the time the Portuguese colonised Brazil, the Brazilian flora has been under threat, for instance, deforestation of the Amazon Rainforest
8	Increased exploitation of Brazilwood
9	Deforestation of our rainforests.
10	The Brazilian flora has experienced several transformations, including changes in climate, deforestation, burning, pollution...
11	During the colonisation of Brazil, the Portuguese began exploring every part of the country, an activity that continues even at present.
12	The almost complete extinction of Brazilwood
13	Every day human beings continue to deforest Brazil, resulting in a pathetic scenario, characterised by the lack of oxygen.
14	The extraction of Brazilwood
15	Portuguese colonisation - Brazilwood exploitation
16	Since the time that the Portuguese colonised Brazil, it has been a drastic devastation of the vegetation in the country. Until the present day, the Brazilian flora has undergone serious damage by burning, flooding, and direct human action, thus decreasing the environmental diversity of the country.
17	Deforestation
18	The exploitation of Brazilwood after the Portuguese arrived in our country
19	Brazil continues to experience almost constant deforestation until today, resulting in a slow but steady destruction of our flora.
20	Construction of the Trans-Amazonian highway.
21	Deforestation of Brazilwood
22	In the mid-1960s, the construction of Brasília promoted the degradation of the Brazilian Cerrado. Another huge factor that contributed towards degrading the Cerrado was the indiscriminate cattle rearing practised there.
23	Portuguese colonisation
24	Wood Exploration
25	The time of clearing up of the Brazilwood
26	The exploration of Brazilwood

Perceived usefulness is "[...] the belief that the use of technology will improve and progress the work or learning activity of an individual or an organisation (Usoro & Echeng, 2015, p. 210)". Fred D. Davis was one of the pioneers to point out that perceived usefulness strongly influences the acceptance of technology (Davis, 1989; Usoro & Echeng, 2015). In this paper we provide elements to confirm his hypotheses, as we demonstrated that students' motivation and academic performance expectancy are positively correlated to their perceptions regarding the usefulness of ICT for the learning of botany.

Table 2 - Descriptive statistics and Cronbach's test of the multiple choice section of the questionnaire.

Question	Mean	Standard Deviation	Corrected item-total correlation	Cronbach's Alpha if item deleted
4	4.204	0.617	0.449	0.722
5	3.898	0.818	0.357	0.730
6	3.917	0.824	0.287	0.739
7	4.197	0.625	0.370	0.729
8	4.248	0.647	0.386	0.727
9	3.745	1.037	0.211	0.757
10	3.013	1.166	0.165	0.771
11	4.000	0.679	0.547	0.709
12	4.064	0.713	0.604	0.701
13	4.025	0.669	0.543	0.710
14	4.223	0.646	0.509	0.715
15	4.287	0.717	0.484	0.715

Table 3 - Spearman's correlation test of the multiple choice section of the questionnaire.

	VB	EU	FC	PU	MU	PE	BI
VB	1.000						
EU	0.078	1.000					
FC	0.084	0.162*	1.000				
PU	0.323**	0.217**	0.195*	1.000			
MU	0.306**	0.084	0.017	**0.703****	1.000		
PE	0.284**	0.205**	0.138	**0.513****	0.489**	1.000	
BI	0.263**	0.255**	0.031	0.475**	0.431**	0.476**	1.000

VB = Value for the learning of botany; EU = Perceived ease of use of ICT; FC = Facilitating conditions for the use of ICT; PU = Perceived usefulness of ICT for the learning of botany; MU = Motivation to use ICT for the learning of botany; PE = Academic performance expectancy by using ICT in the learning process; BI = Behaviour intention for using ICT; ICT = Information and Communication Technology. *p < 0.05; **p < 0.01.

Several studies have indicated that technology enhances the students' motivation for science learning (Osborne & Hennessy, 2003; Bingimlas, 2009; Rolando et al., 2013). Many technological resources can be used in scientific activities, for instance, tools for data capturing and for assembling dynamic imagetic presentations; software dedicated to process simulation and virtual experiments; digital recording and projection equipment. These and other technological resources can stimulate the students' attention and provide additional time for meaningful discussion (Osborne & Hennessy, 2003).

Botanical game and students' interviews

During the game, the student groups correctly identified an average of 8 native plants and about 7 clues were accessed per group. The groups that accessed more clues successfully identified more plants. It is relevant to point out how interested and involved the students were in the activity and also the collaborative work developed all along. Matos et al. (2015) also used a game to teach botany. They reported the students' active participation, interest and involvement during the activity, whose objective was to present some aspects about the morphology and the ecological significance of bromeliads. The authors confirmed that the playful characteristic of the activity stimulated the memory and reasoning abilities of the students.

According to Prince (2004, p. 1), collaborative learning can be defined as "[...] any instructional method in which students work together in small groups towards a common goal. As such, collaborative learning can be viewed as encompassing all group-based instructional methods, including cooperative learning". The Brazilian educational guidelines indicate that group work can help students' self-monitoring and self-confidence. It can also enhances the division of responsibilities among the students (Semtec, 2002).

Cooperative work among students has been shown to be an effective strategy to improve the learning process according to authors such as Springer et al. (1999) and Prince (2004). From this perspective, the game used in our work is an example of how a simple playful activity that involves technology can stimulate the collaboration and cooperation among students. Games can improve the students' spontaneity and creativity and enhance the ability for communication and self-expression. In addition to that, games can also help teachers to improve their knowledge about active learning strategies (Semtec, 2002).

When interviewed, all the students answered that they found it important to learn about the Brazilian flora and its history. A few common arguments can be highlighted from their answers, such as: the pervasiveness of plants in their daily life; the necessity to learn more about the Brazilian flora in order to preserve it; the usefulness of plants; and the rich biodiversity of Brazil. A few answers were selected and are listed below:

> Pupil 1: Of course. Such learning will help us to preserve the different native plants from Brazil. Therefore, we could have more sustainable thinking regarding the subject.
>
> Pupil 2: Yes, I think. Because it is important to know how to identify the plants that we don't know to learn their possible uses.
>
> Pupil 3: Yes, in addition to all the benefits that flora adds to our lives, it is present throughout the historical context of our country. We have to know more about our flora, because how can we take care of what we don't know?

From the data collected in the interviews we can learn that the students consider important to know more about the Brazilian flora. These data corroborate the results observed in questions four to eight which revealed that students attribute value for the learning of botany as the average of these questions varied between 3.898 and 4.248 (Table 2). Wandersee & Schussler (1999) used the term 'plant blindness' to describe:

> […] (a) the inability to see or notice the plants in one's environment; (b) the inability to recognize the importance of plants in the biosphere and in human affairs; (c) the inability to appreciate aesthetic and unique biological features of the life forms that belong to the Plant Kingdom; and (d) the misguided anthropocentric ranking of plants as inferior to animals and thus, as unworthy of consideration (Wandersee & Schussler, 1999, p. 82).

Our research showed that Brazilian secondary students had overcome this misconception and attribute value for the learning of botany. Therefore, now is a good time to rethink our educational

methodologies, because perhaps the lack of interest for the learning of botany is not due to the subject itself, but to the methods used to teach it.

According to Katon et al. (2013), the mere use of lectures to teach about plants can cause the students to quickly become tired and lose interest in the process of learning botany. A non-contextualized approach, focused on memorization can result in the decline of students' enthusiasm. So, a 'vicious cycle' is triggered. The teachers use this poor degree of students' interest to justify their own apathy and, on the other hand, students highlight that the boring lectures are the main causes of their own apathy. These authors also emphasize that educational strategies including games, conceptual maps, and hands-on activities can motivate students for the learning of botany.

Final considerations

From the analyses of the open-ended section of the questionnaire we can learn that most of the students have a limited understanding regarding the Brazilian flora and its history. However, the interviews and the multiple choice questions showed that they consider important to learn botany. The students indicated that technology can facilitate their learning process. In this sense, 'perceived usefulness' was a determinant factor in their opinions. This factor was highly correlated to the students' motivation to use technology for the learning of botany and to their academic performance expectancy.

The collaborative work among the students was evident during the playing of the botanical game. The playful characteristic of the game and the use of technology facilitated the collaboration and communication among the students. Other relevant aspects were the involvement and interest of the students. Having the problems of Brazilian secondary education in mind, it is necessary to rethink educational strategies which can motivate our students. The use of games and also the inclusion of ICT are examples of strategies that can enhance an active and meaningful learning. Therefore, the students can effectively participate in their own learning process.

In the interviews, the students expressed the necessity to learn more about the Brazilian flora to know the ways to preserve it. Although this is not the only factor involved in the students' attitudes towards the flora, it is definitely a decisive one. Whatever is unknown cannot be protected, so the knowledge about the native fauna and flora is necessary to preserve it.

Future studies should include more students from the secondary education to ensure more general conclusions regarding the interests of them in the learning of the native flora. Further research should also involve the teachers who are essential for the necessary changes in the educational methods to teach botany in Brazil.

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Appendix 1- Questionnaire used in the survey

Instructions

(1) This online questionnaire requests your opinion regarding the learning of botany in general and particularly about the Brazilian flora. There is no right or wrong answer; only your opinion is required.

(2) It is important to clarify that the term ICT (Information and Communication Technology) used in this questionnaire refers to the combination of computer technology with telecommunication technology. It is best exemplified by the Internet. If these technologies are used to support student' learning, it can be regarded as a sub-domain of the Educational Technology (Miranda, 2007).

(3) If you need to alter any answer, you are free to do so. When you come to the end of the questionnaire, please press "save answers and send". Please ensure that all the questions are answered. We ensure that all data will be treated confidentially. Thank you for your gracious participation.

Please provide the following details about yourself

(1) Gender:

(2) Age:

(3) Year of secondary school that you are currently studying in:

(4) Name of your school:

Please share your knowledge and opinions with us

Section 1. This section has three open-ended questions. If you wish to give a positive answer write it on the space next to each question. If negative, simply write "No".

Nº	Question	Space for the answer
1	Can you name some examples of plants from Brazilian flora?	
2	Can you name the predominant biome in the northwestern region of the Rio de Janeiro state?	
3	Can you recall some episodes regarding the history of the Brazilian flora?	

Section 2. Please answer the following twelve multiple choice questions. If you strongly disagree with an affirmative, press 1; if you disagree, press 2; if you have no opinion, press 3; if you agree, press 4, and if you totally agree, press 5.

Nº	Question	Strongly disagree	Disagree	No opinion	Agree	Totally agree
4	I believe that it is important to learn botany as I can use that knowledge in my daily life.	1	2	3	4	5
5	I believe that it is important to learn botany as it stimulates my understanding.	1	2	3	4	5

6	In botany, I believe that it is important to develop problem solving skills.	1	2	3	4	5
7	In botany, I believe that it is important to participate in research activities.	1	2	3	4	5
8	It is important to have opportunities to fill my own curiosity when I am learning botany.	1	2	3	4	5
9	I find it easy to use ICT for studying.	1	2	3	4	5
10	The technological resources available in my school to facilitate my studying are sufficient.	1	2	3	4	5
11	I believe that ICT is a helpful tool to improve my knowledge of botany.	1	2	3	4	5
12	I believe that ICT can enhance my active participation in the learning of botany.	1	2	3	4	5
13	I believe that ICT can motivate me achieving the goals in the learning of botany.	1	2	3	4	5
14	I believe that the use of ICT in the learning process can improve my academic performance.	1	2	3	4	5
15	I believe that technology must be used in secondary school.	1	2	3	4	5

Appendix 2 - List of the common and systematic plant names, and references of the illustrations used in the botanical game.

Nº	**Common name**	**Systematic name**	**References**
1	Aroeira	*Myracrodruon urundeuva* Allemão	Martius, C. F. P. von, Eichler, A. W., & Urban, I. (Eds.). (1876). *Flora Brasiliensis*, 12 (2), 400-401, tab. 85. Retrieved from http://florabrasiliensis.cria.org.br/taxonCard?id=FB7998.
2	Pitanga	*Eugenia uniflora* L.	Smith, M. (1915). *Curtis's Botanical Magazine*, 141 [ser. 4, vol. 11], tab. 8599. Retrieved from http://www.plantillustrations.org/illustration.php?id_illustration=7313.
3	Manioc	*Manihot esculenta* Crantz	Thevet, A. (1558). *Les singularitez de la France Antarctique, autrement nommée Amerique: & de plusieurs Terres et isles découvertes de nostre temps*. Paris: Chez les heritiers de Maurice de la Porte, p. 53 and 114.

4	Pineapple	*Ananas comosus* (L.) Merril	Piso, W., & Marcgraf, G. (1648). *Historia Naturalis Brasiliae: In qua non tantum plantæ et animalia, sed et indigenarum morbi, ingenia et mores describuntur et iconibus supra quingentas illustrantur*. Amsterdam: Elzevier, p. 33.
5	Copaiba	*Copaifera langsdorffii* Desf.	Martius, C. F. P. von, Eichler, A. W., & Urban, I. (Eds.). (1870). *Flora Brasiliensis*, 15 (2), 242, tab. 63. Retrieved from http://florabrasiliensis.cria.org.br/taxonCard?id=FB4822.
6	Passion fruit	*Passiflora alata* Curtis	Martius, C. F. P. von, Eichler, A. W., & Urban, I. (Eds.). (1872). *Flora Brasiliensis*, 13 (1), 596-597, tab. 114. Retrieved from http://florabrasiliensis.cria.org.br/taxonCard?id=FB7210.
7	Urucum	*Bixa orellana* L.	Martius, C. F. P. von, Eichler, A. W., & Urban, I. (Eds.). (1871). *Flora Brasiliensis*, 13 (1), 433-434, tab. 87. Retrieved from http://florabrasiliensis.cria.org.br/taxonCard?id=FB6998.
8	Cashew	*Anacardium occidentale* L.	Thevet, A. (1558). *Les singularitez de la France Antarctique, autrement nommée Amerique: & de plusieurs Terres et isles découvertes de nostre temps*. Paris: Chez les heritiers de Maurice de la Porte, p. 120.
9	Brazilwood	*Caesalpinia echinata* Lam.	Pomet, P. (1694). *Histoire generale des drogues, traitant des plantes, des animaux, & des Mineraux* [...]. Paris: Chez Jaen-Baptiste Loyson, & Augustin Pillon, p. 119.
10	Jaborandi	*Pilocarpus jaborandi* Holmes	Smith, M. (1896). *Curtis's Botanical Magazine*, 122 [ser. 3, vol. 52], tab. 7483. Retrieved from http://plantillustrations.org/illustration.php?id_illustration=5020.
11	Acai	*Euterpe oleracea* Mart.	Martius, C. F. P. von. (1823). *Historia Naturalis Palmarum, volumen secundum, Genera et species que in itinere per Brasiliam* [...]. Lipsiae: T. O. Weigel, tab. 28 and 29.
12	Guarana	*Paullinia cupana* Kunth	Martius, C. F. P. von, Eichler, A. W., & Urban, I. (Eds.). (1897). *Flora Brasiliensis*, 13 (3), 372-374, tab. 84. Retrieved from http://florabrasiliensis.cria.org.br/taxonCard?id=FB18002.
13	Victoria Regia	*Victoria amazonica* (Poepp.) J. E. Sowerby	Allen, J. F. (1854). *Victoria Regia; or the great water lily of America, with a brief account of its discovery and introduction into cultivation: with illustrations by William Sharp*. Boston: Printed and Published for the author, by Dutton and Wentworth, p. 23.
14	Cupuaçu	*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum.	Martius, C. F. P. von, Eichler, A. W., & Urban, I. (Eds.). (1886). *Flora Brasiliensis*, 12 (3), 76-77, tab. 17. Retrieved from http://florabrasiliensis.cria.org.br/taxonCard?id=FB14932.