Modern Environmental Science and Engineering (ISSN 2333-2581)
October 2016, Volume 2, No. 10, pp. 654-663
Doi: 10.15341/mese(2333-2581)/10.02.2016/003
Academic Star Publishing Company, 2016
www.academicstar.us

Games as Instruments of *Limnoperna fortunei* Prevention and Environmental Education

Claudia de Vilhena Schayer Sabino[1], Andrea Carla Leite Chaves[1], Maria Edith Rolla[1], Ludmila Vieira Lage[1], and Marcela David de Carvalho[2]

1. Pontifícia Universidade Católica de Minas Gerais - PUC Minas, Brazil

2. Companhia Energética de Minas Gerais – CEMIG, Brazil

Abstract: Golden Mussel has caused severe impacts on natural environments altering native biodiversity, ecosystem structure and function, and on man-made structures, causing economic losses. *Limnoperna fortunei* (Dunker, 1857) is having a significant impact on shallow water habitat in the region of cascade reservoirs ecosystem. The Brazilian electric power industry sector will suffer the greatest economic losses if the golden mussel is allowed to spread. Golden mussel surveying and consequently education for the public, means the prevention of problems to energy companies. This paper aims to present a didactic sequence on golden mussels. The production of this sequence is justified by research showing that teachers and students have difficulty understanding environmental issues, especially issues related to water. The purpose is to improve curiosity and stimulate learning in order to contribute to effective teaching-learning process on infestation probability, focusing on prevention, environmental impacts and health risks. Educational products shown here include: game and manual targeted to teachers with information about golden mussel and the game application in a classroom. These products offer current scientific information, using multimedia resources. The main aspects of the issue were addressed through short callouts using simple language, easily understood, associated with images that illustrate the information. It is expected that these materials can, through play activities, contribute to: (1) Bringing scientific knowledge from the classroom and the daily life of students and teachers; (2) Awakening the interest of students and teachers for water contamination problem; (3) contribute to the formation of individuals better informed and more active on environmental and health related issues; (4) bring changes in the attitudes of teachers and students towards the subjects of research.

Key words: environmental education, *Limnoperna fortune*, golden mussel, exoticspecies, reservoirs, hydropower reservoirs

1. Introduction

It is common in schools to find students who have difficulty in learning and discussing of environmental education content (EE) and also to put into practice what has been learned.

In Brazil there are still lack of new instructional resources that facilitate and enable the practice of EE or even a lack of educational planning due to failures on formal education, where teachers often do not know how to execute EE or do not seek alternatives to do it [1].

On the process of acquiring knowledge in EE there is need of democracy, where the teacher are presented as learning facilitators and students as active individuals, thus participating in the activities [2]. Ludic and creative aspects must be in an action plan of EE because the student's sensibility about environmental issues shall occur through a pleasant process with full rational and emotional involvement [3, 4].

In a context with games and resolution of problem-situations or challenges, the students collaborate a lot, and the environment in the classroom becomes more favorable to the work's development: engage more easily, pay more attention, have fun learning and thinking. So, knowing that the

Corresponding author: Claudia de Vilhena Schayer Sabino, Ph.D., research areas/interests: environmental science. E-mail: sabinoc@pucminas.br.

environmental degradation is a global problem and must seek effective solutions to preserve the environment where we live, the inclusion of recreational activities can be an important method for this process [5].

Conventional materials should continue to be used and developed, but there is need for new resources that are able to organize knowledge, so they can be more representative of the real environmental issues [6]. In this case, games and simulations that approach the environment theme, become important to emphasize the role of scientific knowledge in the functions performed by the technology, and the place of the ethical social values in making complex decisions and preparation measures to solve environmental problems.

Several authors believe in playing as one of the strategies, that have the most significant results in the development of environmental activities, attending school spaces or not, citing in their jobs, games and experiences in NGOs (Non-Governmental Organizations), educational institutions: public, environmental and private [7].

The potential of the ludic in the EE is in the very sense that relationships between people and their environment are registered by history and established by the action of culture, in the case here portraited by ludic play culture. This ludic action, intends a valuation of the roots and the process of play as a collective and not individualizing action, and this is where the transformation lies, as a sense of return, return to collective pleasure, the simple act of play, being part of the environment, and physical contact with the group [9].

A joining is necessary between recreational activities and EE, as a means of providing a more effective EE and to move away from traditional forms used in their processing and use [8]. EE should be liberating and cause significant changes in people's lives, and playing does. This winning combination is possible. However, as you develop and promote recreational games and activities on EE practice, it's possible to identify some flaws, which refer to the small scientific production about the theme in various areas of knowledge, the unpreparedness of the education professionals and the dismantling of government agencies [9].

Educational games can be important learning tools in teaching EE practice [10]. The current literature contains several reports of experience with educational games in environmental education [1, 10-12]. These experiments show that games are an effective methodology in the teaching and learning of environmental issues.

This paper presents the development, application and evaluation of the "Meximinó" game, aiming to contribute with learning and disseminating of problems related to the golden mussel invasion in Minas Gerais State, Brazil.

2. *Limnoperna fortunei* and Its Environmental Issues

The degradation and water pollution are currently a major problem due to the negative impacts on the environment, health and economy. These problems may result from natural and / or anthropogenic factors. This resulted from activities using natural resources and the most significant are urbanization, livestock and irrigation. The aimed consequence is the eutrophication, considered a major environmental problem because it is one of the main qualitative and quantitative impacts on rivers, lakes and reservoirs. Actions that cause artificial eutrophication are the inputs of domestic and industrial waste water, artificial drainage, fertilizer contributions used in agriculture, soil erosion and the use of non-biodegradable detergents [13].

Currently, the freshwater all around the world are being invaded by exotic species, brought by ships that normally take on ballast water from the pelagic zones [14]. Amollusk of the family Mytilidae: Limnopernafortunei (Fig. 1) is an exotic and invasive species that has easy adaptation to ecosystems.

The species Limnopernafortunei, commonly known as Golden mussel, is native to Southeast Asia and has invaded South American freshwaters through the Plate river basin in Buenos Aires, via ships from Hong Kong or Korea at 1991. In 1998, the mollusk quickly expanded to higher portions of the Paraná river basin, border of Argentina and Paraguay [15], mainly invading the great rivers at an approximate speed of 240 km/year [16, 17]. In 2001, the species invaded Itaipu's hydropower plant reservoirs, localized in the frontier between Brazil and Paraguay [15].

Fig. 1 ***Limnoperna fortunei*** **fixed on different substrates in CEMIG reservoirs.**

The presence of these organisms is observed in several South American rivers and became a serious environmental issue [18, 19]. Golden mussel tolerates low osmotic potentials, which explains its presence in estuaries, ports, reservoirs of drinking water and hydropower.

The mollusk lives about two to three years, is a dioecious species, has a high reproductive rates and its sexual maturity is achieved in the first year of life. Golden mussels has external fertilization and a larvae requires 30-70 days to settle and attach to a hard substrate [17]. The time for settlement depends on temperature, currents created by winds, gravity (density of larvae relative of the water) and light [20]. These bivalves are successful in colonizing an ecosystem, because it has rapid growth and is often associated with a thin shell, suggesting that most of its energy is channelled for a rapid sexual maturation. Spawning can occur several times a year, especially in regions where the water temperature is higher [21].

Among the features that make the mussels an invasive species of great success stands out its fecundity and high resistance to different environmental conditions. Their colonies reach densities higher than 100.000 organisms per square meter [22].

The impacts related to L. fortuneiranges from removing the particles, causing increased water transparency and decreased phytoplankton community, to the deposition of excrements and pseudo-excrements, which cause changes in the environment sediment and, consequently, the composition of benthic fauna [16]. Also, the settlement of Golden mussels can change the diet of native species or even favors the settlement of other exoticspecies [20, 23].

Golden mussel can also fixate in the openings of native mollusks shells and make it difficult to filter water for feeding, causing their suffocation and consequently death [24]. The main native fish species of São Francisco basin, serrudomalacófago (Franciscodorasmarmoratus), do not digest the L. fortunei's shell. Pacu (Piaractusmesopotamicus) may be a fish species that could help control the golden mussel, once it is already part of their diet [25, 26].

The presence of golden mussels in hydropowers reduces the refrigeration system pipes diameter, causes decrease in the water speed and clogging of filtering systems. It also observes that the bivalves can sink cages used for fish farming and its scale compromises even the water circulation in the internal environment of the tanks [19].

The larvae fixes in all kinds of hard substrates such as metal, plastic, cement and wood, growing wildly in pipelines and other facilities, affecting industries that use raw water such as electricity, water supply, cellulose and irrigation. It interferes in water flow, causing clogging of pipes, filters, pumps, condensers and turbines [27].

Small boats that circulate in rivers, carrying passengers or cargo and sportive and professional fishing ships, can spread the invasive species by smaller ports. The golden mussel can come, in the form of larvae or adults, on the hulls of these boats, motors and fishing gear [28]. Thus, it is important to disinfect the boats when there is a change in the course of navigated water or large distances to be traversed. This care prevents water contamination by the golden mussel or any other species [28].

3. Meximinó Game

This game was developed with the specific purpose of working with young people to study the various aspects related to the Golden Mussel invasion. Because it is a game of pieces, luck cannot be fully discarded, but the player must establish a strategy to seek the best possible score in his round. Each move will probably be different from the previous round, but he should never lose the common sense. The game is made with rectangular pieces, usually with a thickness that gives them a parallelepiped form.

The domino Game has apparently emerged in China, and its creation is attributed to a Chinese soldier named Hung Ming, who lived 243-182 BC. The traditional set of dominoes, known as Sino-European, consists of 28 pieces of stone. Each rectangular faced domino is divided into two square pieces or "ends", which are marked with a number from 1 to 6, or left blank to represent zero. A game of dominoes is equivalent to a deck of cards or a dice game that can be played on an indeterminate variety of ways. The name probably derives from the Latin phrase "*domino gratias*" ("thank the Lord"), said by European priests to mark the victory in a match.

The game used in the present study was made from wood pieces that are 12 cm long, 6 cm wide and 2 mm thick (Fig. 2). The text and images are printed in paper and glued to the piecesof the game set. Fig. 3 presents a demonstrative scheme of this arrangement, which contains 5 questions and 5 answers. P stands for a question, R for an answer. The completed "Meximinó" is presented in Fig. 4. The information about the mussel, and its correspondent words are listed in an attachment.

The game must be played after a class with content discussion about the golden mussel. Before class, a pre-test should be applied to check the students' prior

Fig. 2 Meximinó game.

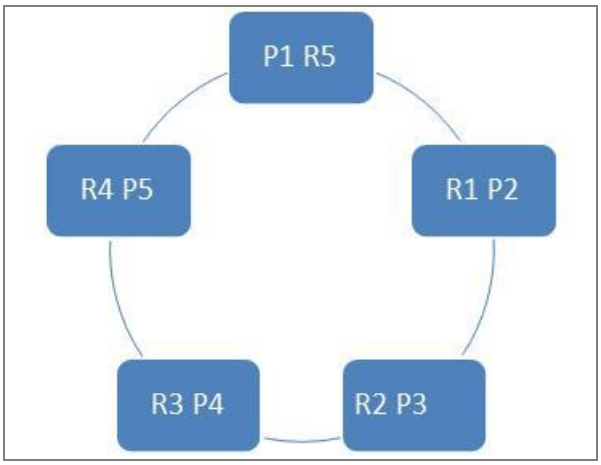

Fig. 3 Demonstrative scheme of piece arrangement in an educational domino.

Fig. 4 Completed Meximinó.

knowledge on the subject. The game was tested in a group of 20 students from a teacher training course. After application of the Meximinó game, a questionnaire was used to verify the retention of information about the Golden mussel and also the perception about the game.

4. Meximinógame Rules

Number of players: 5

Objective: To be the first player to put all your pieces on the table.

***Preparation*:** Place on a table all the pieces face down. The pieces are distributed among the players who must place them with the markings in front of him, so that the other opponents do not see which parts they have.

***Handling*:** The player that has the Golden Mussel piece starts the game by placing it in the center of the table, face up. Then the player on his left start his round, by placing a piece with an information about it next to the side with the mussel image, or a piece with an image, next to the side that has the correspondent information. And so goes on, each player placing pieces matching image with information. If a player has no pieces with correspondent image or information, he should pass his turn, and the player on his left plays.

***Winner of the match*:** the winner is the player who places all his pieces on the table first.

5. Results and Discussion

5.1 Pre-test Questionnaire

The first question was: "What is an exotic species?" According to author Robert Ricklefs [29], exoticspecies are introduced by man into a habitat accidentally (ballast water) or on purpose (ornamental species, biological control). Most students (87%) got it right, showing to have knowledge on the subject. Typical answers are presented in Table 1.

Most of the students knew it mainly because exotic species are present, and cause environmental problems in most cities in Minas Gerais. The fact most discussed by the students was the invasion at the Pampulha lagoon in Belo Horizonte, which was invaded by many exotic species, especially aquatic plants. Another example mentioned was the invasion of capybaras in 2015 [30], a fact widely reported by the media, because the animals were collected and most died in captivity. The invasion of hydroelectric reservoirs by the golden mussel was also mentioned a lot.

The second question was "Name and discuss two exotic species present in your daily lives". The most frequent responses were: rice, bananas, potatoes, cockatiel, elephant, eucalyptus, cat, gorilla, lemon, passion fruit, corn, peacock, beta fish, pigeon, turtle, and tilapia and "I don't know". The answers are correct, although it's debatable whether elephant, gorilla, peacock and other are present in the daily lives of students. No student discussed the response.

The third question was: "Discuss positive and negative aspects of exotic species". Some quotes from the participants with the correction and references that confirm it or not, are presented in Table 2. The answers number 3, 4 and 6 from positives aspects and the answer 7 from negatives aspects are arguable because exotic species can increase, at beginning, the variability of species in aquatic communities, but in the

Table 1 Typical answers to the question: "What is an exotic species?".

Correct answer example	Wrong answer example
Exotic or non-native species are those that live in a habitat, by being inserted through human or rarely natural actions	Are differentiated species with striking distinctive features

Table 2 Answer examples to the question: "Discuss positive and negative aspects of exotic species".

	Answer cited	Correction	Reference
POSITIVE ASPECTS	1. I don't know	---	---
	2. Decoration	Correct	[31; 32]
	3. Increase species variability	Arguable	[23]
	4. Higher diversity as fauna's food	Arguable	[31]
	5. Can be used commercially	Correct	[33]
	6. Can help native species	Arguable	[23]
	7. Food for people	Correct	[31;34]
NEGATIVE ASPECTS	1. I don't know	---	---
	2. Environmental Impact	Correct	[35]
	3. Competition with native species	Correct	[32;35]
	4. Trophic unbalance	Correct	[32]
	5. Can interfere with native species development	Correct	[23]
	6. Turn into plague	Arguable	[32]
	7. Biodiversity Loss	Arguable	[23]

long term, they are not environmentally friendly. Answer 6, from negatives aspects, also cannot be considered correct because the difference between invasive and native species was not mentioned.

5.2 Meximinó Development

The game proceeded in an atmosphere of participation and fun. The class was divided into groups of five students who played with enthusiasm (Fig. 5). Any doubts of the students were clarified by the teacher who acted as mediator.

5.3 Post-test Questionnaire

First Question number was: "What are the main human actions that can accelerate the process of eutrophication?" The answers were: sewage disposal in rivers and lakes (64%), introduction of exotic species (18%), no waste treatment (10%), excessive trash sewage in reservoirs (10%), aquarium water dump in domestic sewage (10%) and release organic matter in inappropriate places (10%). The sum of the percentages is greater than 100% because the students provided more than one answer. All can be considered correct, most cited cause of eutrophication in Minas Geraiswas no treatment of domestic sewage and its disposal in rivers and lakes.

Fig. 5 Students playing Meximinó.

The second question was: "Tell at least three factors that contribute to the rapid spread of the mussel." The most frequent response (30%) was: absence of predators, which is a correct answer, as reported by many authors that this work. Then, 20% said the exotic species are brought by birds, boats, ships, fish, and boat's water disposal, favorable environments, maintenance of irrigation pipelines, hydroelectric plants and food availability. Also correct, although some important aspects such as: contamination of fishing equipment and lack of ships decontamination were not mentioned.

The question number three was: "What are the positives points in this game and what can be improved in the Golden Mussel's activity?" Answers are presented in Table 3.

Table 3 Answers to the question: "What are the positives points in this game and what can be improved in the Golden Mussel's activity?".

Positives points
- Fun and good to fixate the content
- Creative, different and allows to smoothly assimilate the knowledge
- Integration of knowledge
- Easy Interactive and generates association between content and learning
- Interesting
- Reasoning and fun game, at the same time, helps the student to fixate the content in a different way
- Nice
- Very dynamic addition to the student learning, arouses the curiosity to research on the subject
- Enriching and able to stimulate the learning of theoretical knowledge in order to dynamically fixate it
- Very interesting and fun
- Great activity
Points that can be improved
- The rules were poorly explained
- There's room for improvement
- Increase the play time

The most valued aspect by the students was the fact that the game helped fixate contents. In this perspective, the game is not the end but the means that leads to a specific educational content, resulting in a loan from ludic action to acquire information [36]. For Piaget, human recreational activity contributes to the development because it provides decentralization of the individual, the acquisition of rules, the imaginary expression and appropriation of knowledge.

Students appreciated the game's fun. This is a main reason for using this tool, once its effectiveness is due to the fact that it integrates fun and educational aspects in a single teaching strategy [37].

The fact that the students considered that the rules were not well explained was understandable, because as domino is a traditional game, we considered it to be well-known to all, which did not occur. This reinforces the importance of making a detailed explanation of the rules of the game before starting the match.

6. Conclusion

According to constructivism, a person is born with the potential to learn, but this learning can only develop in a dialectical process of dialogue with the world, the interaction with the subject of knowledge and the reflection on the action. Interdisciplinary contents, such as themes related to water, stimulate this dialectical process and are extremely important, because in addition to make possible discussions and relevant interactions, it also predispose the critical formation of the individual. However, for this to occur, effective and motivating pedagogical interventions are needed.

The Brazilian educational process, most of the time, is mediated only by lectures, which may not contribute to the occurrence of significant learning. The game presented in this article was built to support the high school teacher with activities beyond the lecture, allowing stimulative learning, socialization, self-esteem and motivation of students. It was found that the implementation of Meximinó in the classroom context promoted a dynamic that had the teacher as mediator and the students as the central point of sharing, this represented an opportunity for interaction and discussion of environmental and health issues, of rapport and relaxation, and also allowing an proximity

of the teacher with the students .

It is expected that the game will contribute to the appropriation of knowledge about the golden mussels, by teachers and students and that they are motivated to discuss human actions, changes and the environmental impacts that are an important aspect in the practice of environmental education. Thus, the educational game and the strategy presented here may contribute to the process of environmental awareness in students, and to change their behavior. It is hoped that they can make students think about the issues that affect their life and community.

References

[1] D. C. D. Souza and A. F. Nascimento Junior, *Jogos didático-pedagógicos ecológicos: uma proposta para o ensino de ciências, ecologia e educação ambiental, Anais do V Encontro Nacional de Pesquisa em Educação em Ciências*, 2005, pp. 1-12.

[2] N. M. Medina, *Formação de multiplicadores para educação ambiental. O contrato social da ciência, unindo saberes na educação ambiental*, Petrópolis: Vozes, 2002, pp. 47-70.

[3] M. Guimarães, *A dimensão ambiental na educação. Coleção Magistério: Formação e trabalho pedagogic* (5th ed.), Campinas: Eitora Papirus, 2003.

[4] R. A. T. Guerra and C. R. D. C. Gusmão, *A produção de material paradidático implementação da educação ambiental em escolsa públicas*, João Pessoa, PB: Editora da UFPA, 2004.

[5] L. De Macedo, A. L. S. Petty and N. C. Passos, *Os Jogos e o Lúdico na Aprendizagem Escolar*, Artmed Editora, 2009.

[6] Dias, G. F. (2004). Ecopercepção: um resumo didático dos desafios socioambientais. Ed. Gaia.

[7] J. M. K. D. Carvalho and M. Macedo, Brincadeiras e Ensino de Ecologia: Subsídios para uma Educação Ambiental lúdica, 2009, available online at: http://www.ie.ufmt.br/semiedu2009/gts/gt3/ComunicacaoOral/JUAN%20AMARO%20KERSUL%20DE%20CARVALHO.pdf.

[8] L. D. M. Evangelista and M. H. F. B. Soares, Atividades lúdicas no desenvolvimento da Educação Ambiental, Universidade Federal de Goiás. II SEAT–Simpósio de Educação Ambiental e Transdisciplinaridade, Goiânia, GO, 2011.

[9] I. Ribeiro, Ecologia de Corpo & Alma e Transdisciplinaridade em Educação Ambiental, Mestrado em Educação, UNESP-Rio Claro, 1998.

[10] D. M. Da Costa Silva and M. Grillo, A utilização de jogos educativos como instrumento de educação ambiental: o caso Reserva Ecológica de Gurjaú (PE), *Revista Contrapontos* 8 (2009) (2), p.229-238.

[11] A. C. Miranda, R. C. De Albuquerque and R. E. Kneipp, Jogos na web: instrumento de ensino-aprendizagem de educação ambiental no ensino fundamental, *Revista Iberoamericana de Educación* 38 (2006) (2) 7.

[12] P. I. Chapla, D. C. De Souza, A. P. Peracoli, R. De Assis Rodrigues, A. Neiverth and A. F. N. Júnior, Elaboração e produção de material didático: o jogo da memória, como facilitador no ensino de ecologia e educação ambiental, *VII Congresso de Ecologia do Brasil*, Caxambu, 2005.

[13] J. G. Tundisi and T. M. Tundisi, *Os lagos como ecossistemas: Limnologia*, São Paulo: Oficina de Textos, 2008, p. 303.

[14] G. L. Mackie and R. Claudi, *Monitoring and Control of Macrofouling Mollusks in Fresh Water Systems*, CRC Press, 2009.

[15] M. E. Rolla and H. R. Mota, *Response of a Major Brazilian Utility to the Golden Mussel Invasion: Monitoring and Control of Macrofouling Mollusks in Fresh Water Systems*, Boca Raton: Taylor and Francis Group, Boca Raton. Mackie GL and Claudi R., 2010, pp. 396-403.

[16] D. Boltovskoy and N. Correa, Ecosystem impacts of the invasive bivalve Limnopernafortunei (golden mussel) in South America, *Hydrobiologia* 746 (2015) (1) 81-95.

[17] C. E. Belz, G. Darrigran, N. Bonel and O. S. Mäder Netto, Density, recruitment, and shell growth of Limnopernafortunei (Mytilidae): An invasive mussel in tropical South America, *Journal of Freshwater Ecology* 25 (2010) (2) 227-233.

[18] M. D. Oliveira, M. C. Campos, E. M. Paolucci, M. C. Mansur and S. K. Hamilton, Colonization and spread of Limnoperna fortunei in South America, in: *Limnoperna Fortunei*, Springer International Publishing, 2015, pp. 333-355.

[19] K. Bartolomeu, J. Lang, M. A. B. Agustini and K. Heberle, Mexilhão dourado como bioindicador da qualidade da água do Lago de Itaipu em São Miguel do Iguaçu, PR. *Revista Cultivando o Saber* 6 (2014) 85-95.

[20] D. P. Da Silva, Aspectos bioecológicos do mexilhao dourado Limnoperna fortunei (Bivalvia, Mytilidae), Doctoral dissertation, Universidade Federal do Paraná, 2006.

[21] D. Cataldo, D. Boltovskoy, J. L. Hermosa and C. Canzi, Temperature-dependent rates of larval development in Limnopernafortunei (Bivalvia: Mytilidae), *Journal of Molluscan Studies*71 (2005) (1) 41-46.

[22] D. Boltovskoy, N. Correa, D., Cataldo and F. Sylvester, Dispersion and ecological impact of the invasive

freshwater bivalve Limnopernafortunei in the Río de la Plata watershed and beyond, *Biological Invasions* 8 (2006) (4) 947-963.

[23] G. Darrigran and C. Damborenea, Ecosystem engineering impact of Limnoperna fortunei in South America, *Zoological Science*28 (2011) (1) 1-7.

[24] M. N. Lopes, J. P. Vieira and M. D. M. Burns, Biofouling of the golden mussel Limnoperna fortunei (Dunker, 1857) over the Anomura Crab Aeglaplatensis Schmitt, 1942, *Pan-American Journal of Aquatic Sciences* 4 (2009) (2) 222-225.

[25] J. A. Lösch, W. G. Boscolo, A. Feiden, E. K. Lorenz and F. Bittencourt, Presença de mexilhao dourado no trato gastrointestinal de três espécies nativas de peixes cultivadas em tanquesrede no reservatório de Itaipu. Anais do I Seminário Internacional de Ciência, Tecnologia e Ambiente, Cascavel, 2009.

[26] D. Cataldo, Trophic relationships of Limnoperna fortunei with adult fishes; in: D. Boltovskoy (Ed.), *Limnoperna fortune: The Ecology, Distribution and Control of A Swiftly Spreading Invasive Fouling Mussel*, London: Springer, 2015, pp. 231-248.

[27] D. Nakano and D. L. Strayer, Biofouling animals in fresh water: biology, impacts, and ecosystem engineering, *Frontiers in Ecology and the Environment* 12 (2014) (3) 167-175.

[28] G. Darrigran and M. C. Damborenea, *Introdução a Biologia das Invasoes – O Mexilhão Dourado na América do Sul: Biologia, Dispersão, Impacto, Prevençao e Controle*, Cubo Multimıdia Ltda, Sao Carlos, 2009.

[29] R. E. Ricklefs, *The Economy of Nature* (6th ed.), W. H. Freeman, New York, 2008.

[30] J. H. Vale, Técnicos avaliam situação de capivaras capturadas na Lagoa da Pampulha. Notícia do site Estado de Minas – Gerais, 2015, available online at: http://www.em.com.br/app/noticia/gerais/2015/03/27/interna_gerais,631853/tecnicos-avaliam-situacao-de-capivaras-capturadas-na-lagoa-da-pampulha.shtml.

[31] A. A. Silva and L. D. H. C. Andrade, Utilização de espécies de Asteraceae por comunidades rurais do Nordeste do Brasil: relatos em Camocim de São Félix, Pernambuco, *Biotemas* 26 (2013) (2) 93-104.

[32] V. Loges, A. C. R. De Castro, S. S. L. Silva and A. V. V. Montarroyos, Plantas utilizadas no paisagismo no litoral do Nordeste, *Revista Brasileira de Horticultura Ornamental V* 19 (2013) (1) 25-32.

[33] A. A. Faria, T. L. De Melo and B. D. S. F. De Faria, Diversidade biológica x diversidade cultural: uso de espécies vegetais nativas e exóticas em bebidas alcoólicas nos comércios populares no vale do Araguaia, *Revista Eletrônica Interdisciplinar* 1 (2014) (11).

[34] L. M. P. S. Cardel, M. A. J. De Oliveira, M. L. S. Guedes, and F. A. Santana, O uso das plantas e o saber tradicional em três comunidades Ribeirinhas do Rio São Francisco, *Revista Cadernos de Ciências Sociais da UFRPE* 1 (2012) (1) 128-151.

[35] S. R. Ziller and M. De Sá Dechoum, Plantas e vertebrados exóticos invasores em unidades de conservação no Brasil, *Biodiversidade Brasileira* (2014) (2) 4-31.

[36] T. M. Kishimoto, *Jogo, brinquedo, brincadeira e a educação* (14th ed.), Cortez, São Paulo, 2011.

[37] G. N. Mathias, O Uso de Jogos Pedagógicos no Ensino de Química: uma perspectiva do Enfoque CTS, São Paulo, SP, 2009.

ANNEX Questions and answers used in Meximinó

	Questions	Answers
1	The mussels cause trouble to the water supply in cities by obstructing _____	Waterintakepipes
2	It is known as _____. Causes reduction in diameter, increased corrosion of pipes, grill obstruction, Pipe clogging in water pipes, sewage and irrigation	Macrofouling
3	The mussels kill by suffocation when attached to them; They are also bivalves and compete with mussels for space and food. They are the_____	Mollusks
4	Have diminished their communities in the waters filtered by golden mussels.	Zooplankton
5	When it is contaminated with mussels, occurs change in its quality and its smell, its color and taste are changed, making it unfit for consumption.	Water
6	They contribute to spreading the mussels, through fishing equipment, boats or when using mussels as bait.	Fishermen
7	To prevent the spread of mussels, the entire boat and fishing equipment, nets, buoys, should be clean before transporting them from a contaminated area to another. For this we can use water jets and scrape the surface with the use of: _____.	Spatula
8	It is a clam. It grows and reproduces rapidly. It does not have predators, parasites or competitors. Colonizes various types of habitat and live in colonies: _____	Golden Mussels
9	They perform photosynthesis and when grabbed in engines of ships or fishing gear may contain mussels.	Macrophytes
10	The mussels are not eatable. They accumulate pseudofezes, toxic substances, metals and toxins. Moreover, they are hosts of: _____	Bacteria
11	Mussels are bivalve mollusks, equipped with a soft body, devoid of skeleton and protected by a calcareous shell. The term Bivalve means?	Shell with two-piece closed with bilateral symmetry
12	They are invisible and microscopic. May be carried in water that have fishes, in natural flow of rivers, the feet and beaks of birds; on aquatic plants and live bait nurseries.	Mussel larvae
13	Is the origin continent of the golden mussel?	Asian continent
14	It is used in cleaning of boat hulls and fishing equipment contaminated with mussels at the rate of 0.5 liters for every 10 liters of water. It is also used in household cleaning	Bleach (sodiumhypochlorite)
15	They feed on mussels, however, many die, because their intestines become clogged with shells. They also contribute to dispersion of mussels.	Fishes
16	It is placed in the holds of ships for balance and does not undergo any treatment. It is released on arrival at ports, bringing exotic species such as mussels, contaminating new environments.	Ballast water
17	They contribute to spread of the mussels because the larvae may be present in their feet and beaks.	Birds
18	Is a chemical method of combating mussel based on resins, however, it has poor adhesion and is easily damaged. In addition, it may cause environmental damage and contamination risks	Anti-adherent paint
19	It is a method that uses sound frequencies to exterminate the mussels, changing their mobility and reproduction.	Acoustic method
20	The mussel fixating capacity occurs on surfaces through a protein structure produced by the mussel foot glands, known as byssus, which works as a kind of ___.	Glue
21	To prevent the spread of the mussels, if the weather is hot and dry, we should leave the contaminated boats out of water for 6 or 7 days. So the mussels die. We collect them and take them away from watercourses and then add: _____	Lime
22	It is used in chemical methods of eliminating mussels. They are oxidizing agents that prevent the settlement of the mollusks. Block the oxygen and feeding of the mussels	Chlorine dioxide
23	The mussels interfere with its operation since its turbines need to be shut down for cleaning and removal of mollusks. This causes interruption in the supply of light in our homes.	Hydroelectric Power plants
24	It is a gas whose reduction or absence is a physical method of controlling mussels	Oxygen
25	It is a physical method of controlling the mussels using phenomena related to attraction and repulsion of materials and cause tissue degeneration associated with breathing, and other specific structures connected to gas exchange and nutrition.	magnetic method
26	Place where we can find Mussel larvae, widely used at home for fish and plants.	Aquarium
27	As a measure to prevent the spread of mussels, one should never dispose irrigation water or fish breeding water in rivers, lakes or sewers. The water must be disposed of in:____	Dry soil, distant frombodies of water
28	It is a physical method that generates electric field in the middle and between the mussels causing death or stun and preventing their larvae from attaching to the pipes.	Electrical method