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**PLAYFUL LEARNING AND ICT FOR TRAINING SCIENCE
TEACHERS: COORDINATING A TEACHING-INNOVATION
PROJECT**

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Abstract

The problem statement of this study is the contribution to science-teacher training based on playful learning and the use of ICT tools. The research question is: How can we best contribute to science-teacher training and foster playful-learning approaches while motivating the use of ICT tools? The aim is to stimulate teachers in training to design and conduct educational approaches based on playful learning for scientific education, promoting the use of ICT as educational tools. With this objective, a teaching-innovation project was financed and developed for the higher education of kindergarten, primary, and secondary pre-service teachers, at the University of Granada, Spain, since 2015 to 2017. For kindergarten pre-service teachers, three teaching proposals were developed, the first in a course concerning formal and non-formal contexts, the second related to their practical professional training, and the third at their end-of-degree project. The proposal for primary pre-service teachers was also related to their internship training the last semester of their degree. For secondary teachers in training, a proposal was made regarding the end-of-Master's project. By the end of the proposals, teachers in training were able to design and develop educational approaches based on playful learning for scientific literacy, together with cross-curricular skill development. They also showed an improved ability to use ICT tools as educational resources. We conclude that the teaching-innovation project presented is composed of successful proposals devoted to spreading playful learning for science education among pre-service teachers of different educational stages.

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Keywords: Science education, teacher training, playful learning.



1. Introduction

In the modern world, which is changing at an ever quickening pace, new difficulties arise in the workplace that may cause unprecedented situations among professionals. The University ought to face this reality, given its social responsibility as an institution to train qualified professionals, who must be able to permanently build their own careers. The challenge we face involves changes at all levels, especially including teaching practice.

The Spanish journalist Miguel Ángel Gozalo (2014) compiled the notes on his conversation with the Secretary of Education of Spain. We draw attention to the criticism of these notes to a university training system that prioritizes the memorization of content vs. the resolution of complex problems. In their passage through the university, students should learn to be innovative and develop their creativity and critical ability. According to the Secretary of Education interviewed, the training received by teachers could be related to the stagnation that is observed in the students of obligatory levels of education in the areas of science and mathematics in Spain.

On the other hand, professionals in many fields of science, engineering, and mathematics point out the need for innovative and creative thinkers in their professions (Bergen, 2009). Specifically, scholars advocate play-based learning methods to assist students in developing the intellectual skills required for excellence in these fields. Nevertheless, “the educational and social-political climate in many countries does not usually support playful learning, even though professionals in computer science, physics, mathematics, engineering, and other scientific fields stress its value.” (Bergen, 2009, pp.422-423). Moreover, game-based teaching-learning methods disappear from classrooms as the educational level increases and “even in the younger grades, current trends are moving against playful learning. In new guidelines for pre-school teaching in the United States, the word “play” never appears” (Resnick, 2006, p.3).

An example of a response to this situation was the decision of the Education Committee of the Spanish Congress to unanimously support a proposal to introduce chess in the primary school classroom (García, 2015). This decision was preceded by the analysis of various scientific studies by the European Parliament in 2012, before recommending the introduction of chess into the education system of all countries. In Spain, there are already centers of the obligatory educational stages attached to this initiative that confirm the effectiveness of playing in the teaching-learning process (Vidal, 2015).

It is well known that the experimental sciences are matters that, although children initially like them, with the passage of time become the ones that raise the most difficulties. Possible causes include lack of teacher self-confidence and the belief that they are difficult subjects. We believe that the experimental sciences can be approached in the stages of compulsory education in a playful and interdisciplinary way.

For young children, there is no difference between playing, learning, and working: play is their primary learning path. Even for older children and adolescents, games promote high levels of attention and concentration that can be applied to the learning of science because, with a suitable design, games increase a key element in learning: motivation (Kirriemuir & McFarlane, 2004; Denis & Jouvelot, 2005), while stimulating certain capacities, especially those related to the sciences. Such is the case of creativity, which improves the ability to solve problems (Bergen, 2009, Hirsh-Pasek & Golinkoff, 2008).

Incorporating teaching-learning methodologies based on the play that deal with the treatment of experimental sciences is an excellent way to avoid failure in future educational stages, while at the same time providing security to teachers. This approach also helps dispel the image of science as abstract and remote from people's lives. We wonder: what is more human and closer to people than playing? Joan Huizinga (1950) supported the idea in his key work: *Homo Ludens*.

Other well-known authors defended the educational value of playing. For Maria Montessori (1964) to educate is to develop the senses, to relate them to language and this to the intellect. Her method is based on the use of manipulative resources structured for scientific learning, under the motto: "learning by doing". Ovide Decroly (1965) proposed a methodology based on the spontaneous observation of the natural environment and the development of curiosity in its "centers of interest". Materials commonly used in everyday life are their resources for children to learn by playing to simulate the lives of adults. The work of Friedrich Froebel (1912) was based on the scientific principle of opposites to achieve learning and proposed "gifts" (*Froebel Gifts or Fröbelgaben*), i.e. objects-toys with geometric shapes as gifts to children to structure their minds.

Due to the validity and timeliness of this theoretical basis, the present work relies on it in an effort to unite science and play in an innovative project to train future education professionals. Relating culture, science, and game, we strive to promote the idea of access to the sciences in a playful way that foster an attractive and intriguing image of science. As trainers of professionals related to science and technology education, we aspire to a new commitment with an innovative methodology that considers play as an educational foundation at the university level.

In addition, it is important to draw students' attention to reflection and metacognition and to encourage them to have goals that foster self-management of intellectual and professional growth. This requires a great motivation on the part of those who are in training so as to enable them to develop a true regulation of their own learning. In this sense, the incorporation of the educational potential of the Empowerment and Participation Technologies (EPT) plays a fundamental role.

For a long time, in addressing digital competence, the focus was exclusively on providing students and teachers with the training to master the technology, without emphasizing the methodology. The trend of recent years has led to the emergence of LKT (learning and knowledge technologies) concept. LKT seek to orient information and communication technologies (ICT) towards more formative uses, both for the student and for the teacher, in order to learn more and more effectively. The idea is to focus on the methodology, the uses of technology, and not only on ensuring the mastery of a series of computer tools. The idea is to know and explore the possible didactic utilities that ICT offer for learning and teaching. In other words, LKT go beyond merely learning to use ICT but rather opt to explore these technological tools in the service of learning and knowledge acquisition.

Recently, the term EPT (Empowerment and Participation Technologies) has been taken a step further. The EPTs retain the same idea of LKTs but taking advantage of the social and participative dimension of the so-called web 2.0 tools. Now, the challenge is to use the potential of these tools to encourage students to become the true regulators of their own learning (de Haro, 2009; de Wintera, Winterbottoma & Wilson, 2010; Grosbeck, 2009; Mansilla, Muscia & Uglierolo, 2013).

2. Problem Statement

Thus, the problem statement of this study is to contribute to science-teacher training based on playful learning and the use of ICT tools.

3. Research Questions

How can we best contribute to science-teacher training and foster playful learning approaches while motivating the use of ICT tools?

4. Purpose of the Study

The aim is to stimulate teachers in training to design and conduct educational approaches based on playful learning for scientific education, promoting the use of ICT as educational tools. With this objective, a teaching-innovation project was financed and developed for the higher education of kindergarten, primary, and secondary pre-service teachers, at the University of Granada, Spain, between years 2015 and 2017.

Thus, it is our goal to propose an innovative teaching methodology based on the play. We understand the playful activity in general as a process of actions that includes: abstract characterization of a real or fictitious context, assumption of norms, divergent thinking, logical strategies, socialization processes, decision making and establishing of consequences or responsibilities of the decisions taken, and ethical awareness. We consider these characteristics of playing to be powerful values that can be put at the service of education and its evaluation.

The objectives of the teaching innovation project designed and developed are listed below. For each of the teaching proposals involved in the project, we will indicate those objectives that are specifically addressed:

- O1 Promote personal initiative, entrepreneurship and the ability to plan, make decisions and take responsibility.
- O2 Carry out activities that enable the responsible use of free time and leisure
- O3 Stimulate divergent thinking, the emergence of new ideas associated with the acquisition of knowledge and its contextualization.
- O4 Promote the theoretical-practical analysis applied to resolving professional problems.
- O5 Develop the scientifically grounded critical spirit.
- O6 Foster the capacity to evaluate with criteria through participatory evaluation.
- O7 Propose guidelines for the preparation of reports or presentations, to enrich the forms of expression and scientific representation.
- O8 Develop teamwork skills with other professionals.
- O9 Encourage self-management of intellectual and professional growth, and regulation of one's own learning
- O10 Build capacity for the appropriate use of Empowerment and Participation Technologies (EPT).

5. Research Methods

From a relativistic epistemological foundation, knowledge can be scientific, professional or quotidian. We try to include the knowledge sources of each of these types, i.e. scientific sources, professional supports, and the cultural as well as social substrata, all of these essential for the construction of knowledge. From this perspective, the socio-cultural context cannot be disregarded but rather serves both as the basis and as the goal for training education professionals. The idea is to combine the importance of personal and social values (fostered through play), appreciation and recognition of professional and scientific procedures, together with the optimization of technological tools, with the goals set by equity and social development.

The methodology developed relies on several techniques which were adapted to the curriculum of each course or topic involved in the project, all having a common basis of social constructivist as cognitive foundation, in which knowledge is considered to be a construction that is achieved through interaction and social consensus, between students and teachers and between equals. This interaction was established in small groups (2-6 students), medium groups (group of practices that varies between 25 and 30 students) and class groups (55-60 students). The techniques that emerged from group dynamics were used, pursuing collaborative learning (working in small groups, peer-to-peer discussions, and pooling of findings). We proposed the use of the tools of the 2.0 web, which may be the most useful in the professional future of the students.

The portfolio was proposed as a product conducive to creative attitudes in various specialties of higher education (Shores & Grace, 2004). Specifically, students were encouraged to develop e-portfolios made up of blogs, with a strong professional focus (Torres & Rodríguez, 2009), through the use of free software (blogs hosted on Blogger). They were also urged to blog short essays related to current topics of professional interest chosen by the students and echoed in the media. The blog posts were shared among the students in the classes.

Overall, we seek to create a community for research and in learning in which students listen to each other, showing respect and building their ideas on those of others and in which interaction between students acts as reinforcement. In all the actions, we promoted creative activities based on the use of the new technologies as well as the feedforward and exchange between the students.

On the other hand, the participation of students in the evaluation process was encouraged. The suitability of this endeavor is convincing to more and more university teachers, since it serves to promote and measure the capacity for evaluation as a skill to be acquired by the students themselves. Therefore, in the case of university degrees aimed at training education professionals, this challenge becomes a necessity. In this sense, it was expected that the use of transparent evaluation standards will favor student involvement in the evaluation. The design of appropriate assessment tools that explain the evaluation criteria can facilitate the implementation of actions in which the students assess whether their own activities or performances or those of their peers conform to the pre-established standards (Airasian & Russell, 2008; Álvarez, 2000; Delgado, 2005; Doehya, Segersb, & Sluijsmans, 1999).

For kindergarten pre-service teachers, three teaching proposals were developed. The first pertained to a course concerning formal and non-formal contexts, the second was related to their practical professional training, and the third involved the end-of-degree project, the two latest in the last semester

of their degree. The proposal for primary pre-service teachers was also related to their internship training the last semester of their degree. For secondary teachers in training, a proposal was made regarding the end-of-Master's project (see Table 01).

Table 01. Teaching training proposals of the project, their addressees and objectives

Teaching training proposal	Addressees	Objectives
Course concerning formal and non-formal contexts	Kindergarten pre-service teachers	O1, O2, O3, O6, O7, O8, O9
End-of-degree project	Kindergarten pre-service teachers	O3, O4, O5, O6, O7
Practical professional training (last semester of the degree)	Kindergarten and primary pre-service teachers	O2, O4, O5, O6, O7, O9, O10
End-of-Master's project	Secondary pre-service teachers	O3, O4, O5, O6, O7

5.1. Course concerning formal and non-formal contexts for kindergarten pre-service teachers

This course was designed to favor the self-regulation applied to the professional training with play as methodology of teaching and learning being the central theme. The following objectives of the project were particularly emphasized: O1, O2, O3, O6, O7, O8, and O9.

In this course we establish four temporal and conceptual stages. In the first stage, the learning process is guided by the classroom sessions (theory and practice classes and practical seminars). The theory and practice classes introduce theoretical notions of noted authors who defend the educational value of play, but with a practical approach, since the student must be actively involved through the performance of classroom activities related to theoretical notions. In the practical seminars, the conceptual and procedural aspects are strengthened. Traditional games of different cultures and various commercialized games are analyzed, following a systematic procedure, guided by a specially designed protocol.

In the second stage, the real professional context is contacted to achieve professional learning through reflective work related to field practice. This practice consists of visits to different contexts of non-formal education, with a marked playful character, both public and private.

In the third stage, what is grasped in the previous stages is put into play, in a specially creative way: designing, constructing, and analyzing an original game devoted to the teaching-learning of experimental sciences (together with other areas of knowledge).

The fourth stage consists of the evaluation, intended as a formative process in which the students participate. After the presentation of the educational games or playful resources of their own design, the students carried out self-evaluations and peer evaluations (co-evaluation), thus favoring the pro-feed. To this end, the same evaluation tool was used in the different modalities: a rubric expressly designed to evaluate the performance of students.

5.2. Practical professional training for kindergarten and primary pre-service teachers

In the practical professional training, the students carried out the creative and original preparation of individual e-portfolios with a professional approach, in the form of blogs. The following objectives of the project were particularly favored: O2, O4, O5, O6, O7, O9, and O10.

Initially, as a guide to the proposal, an e-portfolio model was developed as a blog (Fernández-Oliveras & Oliveras, 2017). For the preparation of their own e-portfolio, all students:

- Commented and reflected on the most relevant aspects of their daily experience in professional practices.
- Sought and analyzed documents related to the topics proposed by consensus, generating short essays that were included in blog posts.
- Made a blog page about teaching and learning in the experimental sciences, considering the relationship between theoretical foundation and professional practice.

During the preparation process portfolios were shown in the classes with the entire large group, incorporating the review between peers and facilitating the feedforward. At the end of the intervention, once the e-portfolios were completed, different participatory evaluation modalities were applied (co-evaluation and self-evaluation). For this, the same evaluation tool was used in the different modalities: a rubric expressly designed to evaluate the e-portfolios as blogs made by students.

5.3. End-of-degree project for kindergarten pre-service teachers and end-of-Master's project for secondary pre-service teachers

In the end-of-degree and end-of-Master's projects, the pre-service teachers faced the design of educational proposal focused on the use of play as a methodology for teaching and learning the experimental sciences. Previously, the students carried out a thorough bibliographical review of the literature on the subject. Our premise was that this topic, besides being novel for end-of-degree and end-of-Master projects, was of great usefulness for training professionals in scientific education.

The following objectives of the project were particularly favored: O3, O4, O5, O6, and O7.

For kindergarten pre-service teachers, the methodology also included an action research to be conducted while considering the following process: the game design (preceded by the bibliographic review), its preparation, implementation, and evaluation together with proposals for improvement, incorporation of changes, new implementation and evaluation, analysis of results, and conclusions.

6. Findings

Teachers in training were able to design and develop educational approaches based on playful learning for scientific literacy, together with cross-curricular skill development. They also showed an improvement in their ability to use ICT tools as educational resources.

6.1. Kindergarten pre-service teachers findings

Regarding the course related to formal and non-formal education, as shown elsewhere (Fernández-Oliveras, & Oliveras, 2016), the reflections of the teachers in training after following our approach

revolved around three interrelated cores: science education, playful learning, and non-formal education. The students revealed the convictions derived from their experience in our teaching approach with statements such as: “We learn to work with math and science with our future students in a playful way”, “New ideas for losing the fear to work on mathematics and science with children, since we have discovered that these subjects are present in almost everything”, “The preparation of the final game also helps raise awareness that it is not so difficult to develop something for the children in an original way”, and “It gives us some knowledge of non-formal environments in which to work, take our students if we work in a (formal) centre” (p.168).

The results of the kindergarten internship training have been presented in a previous publication (Fernández-Oliveras & Oliveras, 2015), showing similarities with those in the following subsection for the primary pre-service teachers involved in the project.

Concerning the end-of-degree teaching-proposal project, the teachers in training found that the project provided knowledge about the creation of educational resources based on playful learning. This helped them develop a more active teaching-learning methodology that integrates in its objectives and contents notions related to the experimental sciences, adapted to the context and age of the students. Also, during the implementation phase, the importance of direct observation as a method of data collection for educational research was verified from the perspective of initial teacher training (Fernández-Oliveras, Molina, & Oliveras, 2015).

6.2. Primary pre-service teachers findings

The primary teachers in training succeeded in developing and evaluating the e-portfolios prepared as professional blogs. In their portfolios, primary pre-service teachers described the most noteworthy aspects regarding their experience at the internship schools and the educational resources that they found the most useful. In their reflections, primary teachers in training revealed their preference for a game-based approach and for playful performances, discussing their experience in the classrooms during the internship period. For example, in his blog, one pre-service teacher involved in the project recounted the visit to the school of a pupil’s mother, who participated in the classroom activities:

“This week I'm going to talk about the space reserved in the schedule for the participation of families. It is normally on Fridays but this week it has been matched with the change of season from winter to spring and therefore is earlier. Dario's mother came to tell us about spring by playing the role of the Spring Fairy. Everyone in the class knew her but the fact that she came in a costume made the activity more fun.” (Martín, 2017).

“This is all we have done during the visit of Dario's mother, but then we have begun to ask us questions about the theme: Why are there seasons? And why does spring start today and not 6 days later, for example? What is the movement of the Earth? How does it move? What if it did not move; what would happen? What would be the effects of always having the same season?” (Martín, 2017).



Figure 01. Photographs taken by a primary teacher in training on his blog: a mother in costume (right) and a puppet theatre (left) for learning about and playing with the seasons of the year (source: Martín, 2017)

During their participation in the project proposal, primary pre-service teachers also demonstrated their good progress in the control of ICT tools as resources at the service of science education, as can be seen from their comments in their blogs: “To these questions, which have been debated in a large group, we added the movement of the Earth turning, and above all revolving around the sun, and all the questions that arose were answered. For this, different resources were used: in addition to the teacher's explanations, some explanatory videos on the movement of the Earth were shown. One of these videos, for me the most interesting, belongs to the blog La Eduteca and can be seen below. We also used the computer application "Google Earth" on the digital display of the classroom. After going around the planet looking for where the school is, where all the continents are, and exploring the world for a while, the program has been used to see what causes Earth movements and to understand the effect of changing its position with respect to the sun (what we used to do with a globe).” (Martín, 2017).

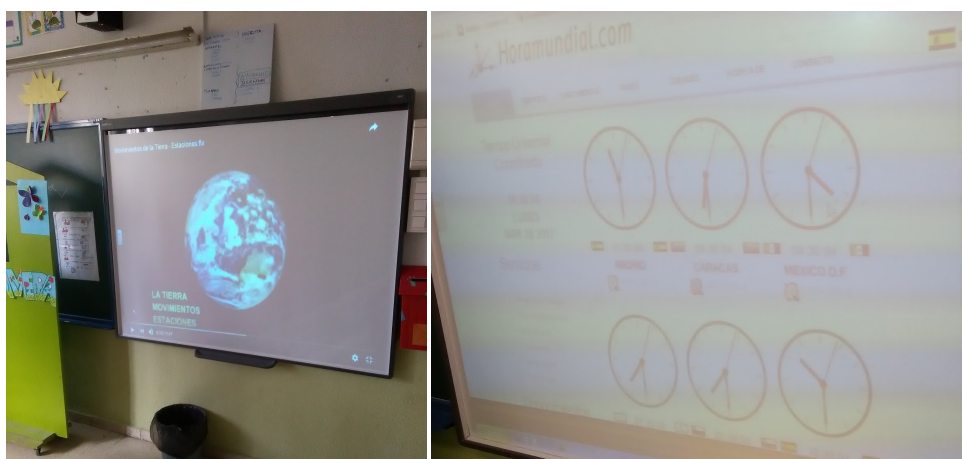


Figure 02. Photographs taken by a primary teacher in training on his blog: using the computer application Google Earth and a website concerning world time on the classroom digital board (source: Martín, 2017)

6.3. Secondary pre-service teachers findings

Regarding the end-of-Master's teaching-proposal project, secondary teachers in training were able to design their own educational approaches based on playful learning for scientific education. They also prepared the materials needed to implement the proposal. An example can be seen in Figures 03 and 04.

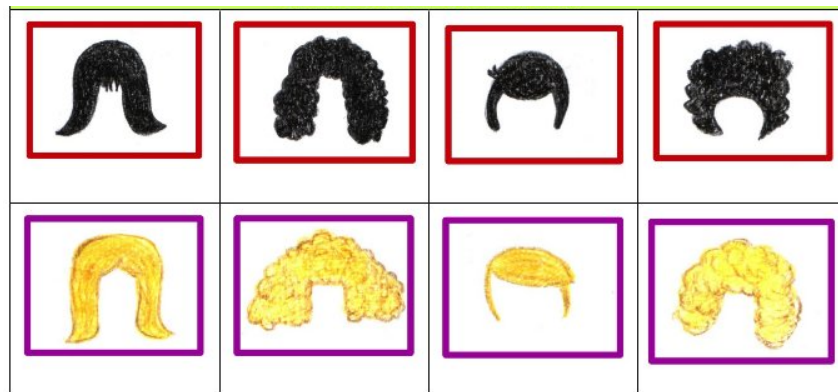
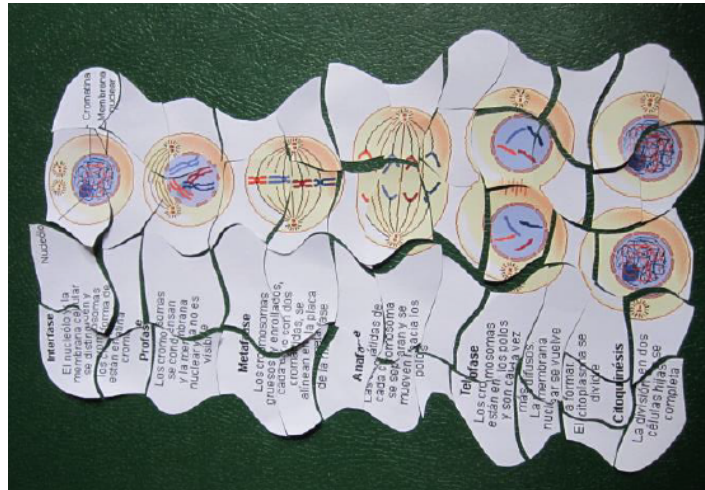


Figure 03. Materials for games related to biology topics, designed by a secondary teacher in training: mitosis puzzle and stickers with wigs for playing with genetics (source: Staffieri, 2016)

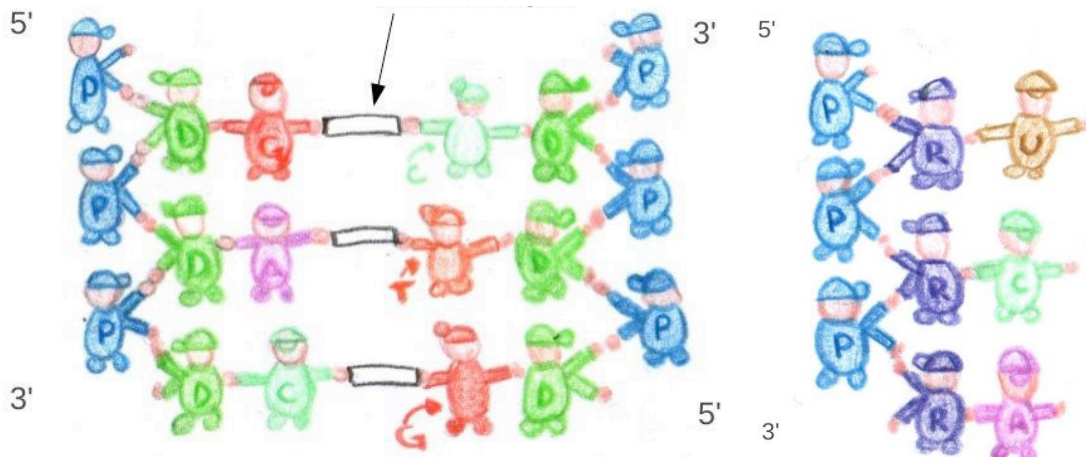


Figure 04. Materials for games related to biology topics, designed by a secondary teacher in training: group recreations of DNA and RNA structures (Source: Staffieri, 2016)

In the words of a secondary pre-service teachers who participated in the teaching-innovation proposal: “The work done has been very useful for me, since it has allowed me to realize the difficulty and complexity involved in developing activities that may significantly favor the learning of scientific subjects. Its preparation has been very constructive for my personal training as a teacher, feeling constantly the leader in the creation of the activities, with the challenge of improving the teaching-learning practice of biology.” (Staffieri, 2016, p.55).

7. Conclusion

The teaching-innovation project presented is composed of several successful proposals devoted to spreading the idea of playful learning for science education between pre-service teachers of different educational stages.

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