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# Teacher-Developed Computer Games for Classroom and Online Reinforcement Learning for Early Childhood

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**Abstract:** During the recent period of confinement, educational institutions and teachers worked together to provide online teaching to enable students to acquire the competencies of each educational level. Efforts mainly focused on secondary and higher education and, to a lesser extent, on primary education. Although these efforts have been useful, it is important to take advantage of them and continue using both the resources developed and the know-how obtained during this period. In this paper, we present an online education proposal with a focus on preschool education that was initially developed during the lockdown period for students between three and five years old, and which continues to form an important part of the curricular content in current face-to-face teaching. We discuss the adaptation and successful use of this proposal in the post-confinement period, in which a return to face-to-face education has taken place. It is important to note that this proposal is aimed at a generation of students who are already digital natives, and it is necessary to pay attention to both the content and the design of the proposed computer games, in addition to maintaining the motivation of the students. One of the differentiating characteristics of this proposal is that the interactive resources developed here were designed, developed and adapted by the preschool children's teachers themselves, without requiring computer science skills. The proposed methodology provides dynamic resources that evolve alongside the students. Therefore, our proposal is composed of both the methodology for the development of the computer games of the game-based part of our curricular project, and the project itself. Two examples of this project are presented. We show how the methodology allows the design and adaptation of computer games for specific school groups at specific learning stages.

**Keywords:** early childhood; online education; educational computer games; teaching/learning strategies; Genially resources; reinforcement learning



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## 1. Introduction

Although distance teaching is not a new concept, it remains a very topical one. For example, UNED, Spain's National University of Distance Education http://www.uned.es (accessed on 3 December 2022), was created in 1972. In the same year, Moore [1] defined distance education as an instructional method in which teaching practices occur separately from the learning process, so that communications between teacher and student must take place by means of printed, electronic, mechanical or other communication techniques. MacKenzie et al. [2], endorsed by UNESCO (United Nations Educational, Scientific, and Cultural Organization), established that a distance educational system must facilitate the participation of all those who want to learn, without imposing traditional admission requirements and without the only reward being an academic degree or any other certificate; the system must be able to overcome the distance between teaching staff and students, and should use this distance as a positive element in the development of learning autonomy.

Peters [3] defined distance education as a method of imparting knowledge, skills and attitudes, requiring the division and organization of the work and making intensive use of technical resources; in particular, this should include the reproduction of high-quality teaching material, so that large groups of students can be instructed at the same time in remote areas through a method defined as the industrial form of teaching and learning. Although the proposal by MacKenzie et al. [2] mainly focuses on the characteristics of the learners, whereas Peters [3]' outlook is mainly focused on the characteristics of the distance education system, both proposals taken together offer great insights.

The proposal presented in this work provides a viable, efficient and effective solution to design and develop distance education proposals for learners from three to five years old. One of the most relevant aspects of the proposal presented is that the resources must be designed and developed by the teachers themselves, thus ensuring that the contents are adequate for each stage of the teaching-learning process, as well as ensuring the motivation of both the students and family environment. Therefore, an essential requirement, fulfilled in our proposal, is that teachers without computer science skills can design and develop these proposals autonomously. This is the main objective of our project, but there are a number of well-known objectives that must also be met in order to develop effective and motivating applications.

The authors if [4] established that "reinforcement learning is learning what to do—how to map situations into actions—to maximize a numerical reward signal. The learner is not told which actions to take, but instead must discover which actions yield the most reward by trying them", paradigm followed in the design of the computer games presented as examples in this article.

This article is based on successful work designed on an ad hoc basis to allow for the continuation of the learning process of children from three to five years old during the period of compulsory confinement. Both the tools necessary for resource development and some resources developed with these tools will be presented, as well as the design process to use the tools most efficiently. We will also explain how this work continues to be useful in normal circumstances, both inside and outside the classroom. The tools used, which were fundamental to the success of the work, and their availability to the global educational community will also be discussed. One of the most important aspects of this work is the methodology used; this work was not a static proposal that once developed would require great effort to adapt to new contexts or requirements; on the contrary, it is an approach with a high degree of dynamism and great adaptability. It should be borne in mind that we are discussing interactive multimedia resources developed by early childhood education teachers. It is important to highlight that the need for technological competency in early childhood teachers, established, for example in [5], can be overcome with the proposal presented in this paper. As stated in [6] it is necessary to address the educational needs of young children at a distance, as well as to work differently with families. It is advisable to keep the space and time of school and home mixed, as well as to promote the sharing of the roles of teachers and parents originally caused by the closing of schools [7]. The proposal presented is also helpful in solving some of the challenges of early childhood education identified in [8], such as parental stress, lack of resources and quality of education. It also addresses the current main disadvantages of online early childhood education, which, as stated in [9] mainly concern limited resources/support for children at home and poor training in online methodology.

In Section 5, we describe the context in which this project was developed. The main goals are discussed in Section 2. Feasible platforms and tools are briefly analyzed in Section 3. In Section 4, we present some examples, including the objectives pursued, the development process and the possibility of adaptation to other curricular projects. Section 7 contains both our conclusions and future lines of work.

*Educational Environment*

Economic globalization, emerging forms of communication and technological innovations are rapidly changing the way we understand today's world and society, and the ways we interact with each other. In the new social reality, new possibilities for interaction will play a leading role in Education 4.0. However, this will require a change in several areas, since technology on its own is not sufficient to guarantee an improvement in education. Children and young people, as learners, must be the protagonists of any pedagogical task, and are also the individuals who will drive change in the immediate future. They must therefore be prepared to face the challenges and uncertainties of the third millennium. The social impact of education has reached unprecedented heights in recent decades.

Modern students are digital natives, and new technologies form an essential part of their reality. These digital natives live in an audiovisual and technologized environment that has created a new communicative ecosystem in which new subjectivities and diverse ways of relating to others have emerged. This reality demands a renewal of socio-educational relationships; teaching processes cannot be based solely on the principles and needs of previous social realities. However, innovation in education does not simply involve introducing more technology into more classrooms. ICTs in themselves do not lead to any innovation in education and learning, nor do they ensure effectiveness in student learning. They should be used mainly to create the possibility of being able to teach and/or learn in a new and different way.

It is important to bear in mind that although educational centers have historically been the main places where teaching and learning have taken place, they are no longer the primary sources of learning. For example, Prensky [10] opposes the traditional teaching model in which theoretical instruction predominates, the teacher possesses all the knowledge and the student assumes the passive role of a spectator. Today, the role of the teacher is more aligned with that of an agent of change who guides students towards a lifelong learning process.

Technology is beginning to be deployed on a massive scale in classrooms, including interactive whiteboards and computers, tablets, smartphones and e-books. One of the objectives of our proposal is that technology should not be exclusively in the form of static audiovisual elements.

The proposal presented here aims to exploit the fact that students have the opportunity to learn outside traditional teaching/learning spaces, anywhere and at any time. In other words, they can carry out ubiquitous learning. Students learn in diverse contexts and situations, without even being aware of it, and in a playful way. A successful choice of the right applications allows students not only to achieve the objectives and acquire the competencies demanded in the educational curriculum, but also to develop their creativity, logical thinking, responsible use of electronic devices, spatial skills and time optimization.

## 2. Main Goals

Long hours of continuous study without breaks inevitably cause learners to detest learning. One way to avoid this, especially at the preschool level, is to use games; these allow the learner to have fun and (if properly designed) to continue learning in a way designed by the teacher. Our proposal allows the development of effective teaching and learning environments to enhance the traditional approach. We easily design and adapt these games (computer games), among other objectives, to effectively break group dynamics without interrupting the learning process, and to motivate the use of these games outside the classroom to allow learners to consolidate knowledge and have fun.

In a real environment, game-based learning typically involves children in a game world that allows them to interact with the learning material while motivating them to improve their knowledge and skills through competitive activities with rules, objectives, feedback, interactions and results (Kim et al. [11]). These objectives remain unchanged in our proposal, since the learning material takes the form of ICT resources that are available both in the classroom and at home.

Although there are many educational applications based on computer games, the educational community as a whole is beginning to question the content, relevance and suitability of these applications, as mentioned above (Papadakis et al. [12]). We cannot isolate children from technology, because they are digital natives who live surrounded by this technology and apps (Guernsey et al. [13], Lauricella et al. [14], Wartella [15]), but we must make sure that it does not harm them (Ebbeck et al. [16], Parette et al. [17]). The mobile application market offers many new digital products for the education of young children (Papadakis et al. [12], Judge et al. [18]). There is an ongoing and intense debate about children's exposure to digital media, and it is perhaps more interesting to pose questions about what they should consume and to place less emphasis on how long it is appropriate for them to consume it, which derives from concerns over the content of the applications becoming more current and complicated (Guernsey et al. [13]). In view of this, our proposal allows us to address two important goals: controlling the content consumed by children and ensuring the relevance of the content. It is important to note that the content was designed and specially adapted to promote the learning path of the teacher, in some cases at a group level and in others at an individual level. It is very important to bear in mind that many applications that include the word 'educational' in their title are not appropriate to the developmental needs of the age group at which they are aimed (Papadakis et al. [12]). It is also necessary to make an effort and pay special attention to both design and content when choosing mobile applications that are supposedly educational in order to achieve productive learning (Falloon [19]). Since there are several works that have highlighted the need for a reliable and effective framework for monitoring and evaluating mobile content through which parents and teachers can download resources with real educational value for preschoolers (Guernsey et al. [13], Kucirkova [20], Tian et al. [21], Vaala et al. [22]), our proposal takes on particular relevance. Several studies (Papadakis et al. [12], Crescenzi et al. [23]) have suggested lines of research for the design of resources to be used in early childhood education environments; these are in alignment with our approach, in which resources are designed by the teacher for the learners.

Many studies over the past decades have shown that learner-centered design addresses the need for learner engagement (Norman and Spohrer [24], Watson and Reigeluth [25], Ruello and Capodici [26]), and this finding is also applicable to preschool education (Yenawine [27]). Our approach aims to enable the design of resources that also meet this objective, that is, the resources designed must be learner-centered. In fact, this is an easily achievable objective, since learners can take part in the design of the resources, either at the design stage or the subsequent adaptation stage. This makes it easier for all members of a group to act as protagonists and, therefore, to be linked and motivated to use the resources.

## 3. Platforms and Tools Analysis

The set of developed resources can be considered as learning objects. It is true that there is no clear definition of learning objects (Smith [28]), since learning objects vary in terms of their size and scope, content, design and technical implementation; hence, pinpointing the essence of a learning object is not an easy task. One aspect that most descriptions have in common is that they focus on how learning objects are created, used and stored, rather than what they look like. A perspective that fits in with our proposal is one in which learning objects are compared to LEGO$^{TM}$ building blocks; in other words, learning objects are small units that can be fitted together and organized in numerous ways to produce personalized learning experiences (Hodgins [29]).

The COVID-19 pandemic required educators from preschool to university levels to unexpectedly shift their teaching practice to online environments. The challenges that needed to be solved to provide this online education are well documented, such as feelings of disconnection (Choudhury and Pattnaik [30]) and the difficulty of responding to individual needs (Haavind and Sistek-Chandler [31]). These challenges, which were suddenly imposed by the pandemic, were faced by all educators and learners, who were

abruptly immersed in this environment and were often unfamiliar with its possibilities. As the work conducted during the pandemic progressed, important issues related to MOOCs emerged, even though the schoolwork was designed primarily in the form of games. It should be noted that teachers must be the designers, developers and facilitators of learner-centered, face-to-face educational experiences, and must become designers and developers who see MOOCs as a way to foster similar learning experiences in an online environment. In the design of this proposal, the differences between connectivist and transmission-oriented MOOCs (Ebben and Murphy [32]) were analyzed with respect to this concern, with the aim of creating learner-centered spaces while still maintaining explicit objectives and content structures.

This choice of tool was important, as it allowed us to overcome the technological impediments that usually prevent the design of resources as desired by teachers. In addition, once a resource has been designed, Genially allows for an analysis of its performance, mainly in face-to-face teaching, and allows designers (teachers) to improve it without high development costs.

In a later section, we will detail some of the resources designed using Genially, the design process itself, and the modification/adaptation process. However, it is first necessary to emphasize that these resources form part of a game-based project that makes use of other technologies and advanced teaching resources. For example, the overall project includes resources designed with Makey-Makey https://makeymakey.com/# (accessed on 3 December 2022), a simple device that implements the Human Interface Device (HID) protocol and is easily connected to any computer via a USB port. No additional software or drivers are required, but it requires computational programming skills using Scratch. Games have also been developed using educational robots, such as Bee-Bot https://www.terrapinlogo.com/bee-bot-family.html (accessed on 3 December 2022); although this does not require special programming skills, the diversity of games that can be developed is limited. Many other non-interactive resources have been designed using Canva https://www.canva.com/ (accessed on 3 December 2022) and some other software applications.

## 4. Game-Based Proposal

Our MOOG2L proposal was designed and developed by teachers using Genially and offered to a group of students between three and five years old. The importance of our proposal is based on two main aspects; the first is that the set of developed resources (of which two are presented here) can be freely used and adapted; the second is that the process of development and/or adaptation of these computer games does not require programming knowledge. This procedure will be described in Section 5.3. Factors that are important prior to development such as the conceptualization or design of the resources form part of the study and planning of the complete curricular design, but will not be analyzed here, as they are beyond the scope of this article.

### *Examples of Developed Resources*

Since we cannot describe all the available resources here, only two of the simplest examples will be presented. These examples illustrate different learning objectives and different levels of interactivity, playability and reusability. It is clear that the starting point for any resource is the learning objective. It should be noted that our working methodology is project-based teaching (Kokotsaki et al. [33], Diffily and Sassman [34]), which makes it difficult to find free resources that fit with both the learning objective and the project in which it is included; similar usable resources that are available involve significant work to adapt them, if they allow for this at all . Our methodology overcomes these drawbacks and allows for the development of resources that perfectly meet the learning objectives and provide the necessary relationship to the project being developed.

The first resource, shown in Figure 1, is based on the well-known game of the goose, or snakes and ladders, in which the main objective is vocabulary learning. The figure shows the most complete version in terms of the number of objectives worked on, which implies

less interactivity. Before explaining the different developments of this game (that is, the different adaptations made according to the ages of the students), the learning objectives and the characteristics that define the group, we will explain the functioning of the game (which is available from https://view.genial.ly/6227bc5b58b95f0019c9ae1b/game-joc-de-labecedari (accessed on 3 December 2022) and, in particular, the version for four-year-old students. As mentioned above, this is a group game and the basic instructions are shown on the screen. The game is modified to suit the age of the students. In the example shown, the group identifies with the tiger from the age of three; as the group is currently five years old (last year of the cycle), the tiger that appears is already an adult tiger. In our method, the tiger is not a mascot; the group identifies with this animal from three to five years old. This choice is made by consensus, each group identifies with a different animal. Adaptation to other groups can be performed quickly.


**Figure 1.** Resource based on the game of the goose, for vocabulary learning.

The game is introduced in the classroom through the use of an interactive whiteboard, with the teacher as a catalyst. Mothers, fathers and/or guardians are informed so that the game can continue at home with a family member acting as the teacher. In one of the versions provided to families, some letters are replaced by photos of the students in the group, which allows families to identify all the members of the group (after all necessary measures have been taken to comply with data protection laws; moreover, these resources are obviously made available only to families). After developing a base resource, we also need to create adaptations that motivate the learner to carry on using the resource and to continue the learning process both inside and outside the classroom.

As mentioned above, from the basic resource, the game evolves over time in terms of both purely aesthetic and functional aspects as learning takes place. All versions of the resource are stored using the service provided by Genially https://genial.ly/ (accessed on 3 December 2022), but only appropriate versions are made public for the groups of learners. The version shown in Figure 2 is available to the trainee group at https://view.genial.ly/5eaaf3cbeacf4c0d6715ddb5/game-joc-del-nombres (accessed on 3 December 2022).

It is worth mentioning that a specific version can be developed for students with learning disabilities that includes topics that are particularly motivating to them and that are aligned with the learning objectives, integrating them into the group using almost the same resources.

Starting from the basic resource described above, a similar game was developed with different learning objectives than the previous one. In this game, the main objective was knowledge of numbers at both mathematical and written levels. Figure 2 shows this game, with the letters replaced by numbers represented in different ways.


**Figure 2.** Resource based on the game of the goose, for mathematical learning.

The second example is a game with objectives related to language and discovering new words, but also designed as a basic tool for the overall project that was developed with the objective of learning what insects are, recognizing some of them and knowing their role in nature. We created a version of the game that contains screens of the games developed for three-, four- and five-year-old students, which is available at https://view.genial.ly/6232219fa4a8c800181e4e79/learning-experience-challenges-el-insectes (accessed on 3 December 2022). Students discover new words or new insects and, because it is the teacher who designs the game, it is the teacher who expands it with the words and insects that, according to the project under development, are appropriate to the current learning moment; see Figure 3. The game is structured as a flip screen game in which the first screen, shown in Figure 3a, is the presentation of the game. The next screens (Figure 3b–d each address a word for three-, four- and five-year-old students, respectively, for which they must order its letters. If ordered correctly, by dragging and dropping, the students can watch a short video about the insects and then move on to the next screen. The screen shown in Figure 3b corresponds to the version of the game released for three-year old students. The main objective is to recognize the letters, as well as to order the letters correctly; therefore, both the correctly written word and the disordered letters are shown. Figure 3c shows an example of the version developed for four-year-old students, in which the correctly spelled word is removed but some letters are added to help the learner obtain the correct solution. In the version for five-year-olds, shown in Figure 3d, only the unordered letters are available to help the student obtain the correct word. Once the ordering of each word has been completed, it must be checked before the learner can move forward or retry, as shown in Figure 3e. As the game is designed as a flip screen game, the student can switch from one screen to another, which breaks up a possible demotivating routine that may discourage the use of the resource. An example can be seen in Figure 3f.


(**a**) (**b**)

(**c**) (**d**)

(**e**) (**f**)

(**g**) (**h**)

(**i**) (**j**)

**Figure 3.** Screens of the insect game. (**a**) First screen of the insect game. (**b**) Screen of the insect game (for three-year-olds). (**c**) Screen of the insect game (for four-year-olds). (**d**) Screen of the insect game (for five-year-olds). (**e**) Screen of the insect game (check task). (**f**) Screen of the insect game (break routine). (**g**) Interactive screen 1 (start). (**h**) Interactive screen 1 (correct). (**i**) Interactive screen 2 (using). (**j**) Interactive screen 2 (not correct).

## 5. Context

We here introduce the most relevant aspects of our proposal in regard to the teaching–learning process, as well as aspects related with the students, the teachers and the environment in which the transfer of knowledge and skills takes place.

### 5.1. Learners and Game-Based Learning

Our proposal is aimed at children from three to five years of age; although our tools and methods could even be extended to university teaching and post-graduate learning, our developments focused on this early period of life. Motivation is undoubtedly key to successful academic performance, and there is a general consensus that it is influenced by four factors: situation (the external environment and stimuli), temperament (the state and internal state of the organism), goal (the behavioral objective, purpose and direction) and instrument (the tool used to achieve the goal). There is also agreement that there is a strong correlation between motivation, as a crucial catalyst for successful learning, and academic performance (see, for example, Corpus et al. [35], Juriševič et al. [36]), regardless of the subject or the age of the learner. Although it is clear that the four factors listed above do not change according to the age of the students, it is worthwhile to take into account the age range of the users of the proposed scheme when analyzing these factors.

Considering the age of the students, their main motivation is to be happy and have fun. There are undoubtedly other motivating factors such as helping their parents, socializing, using their parents' tools, etc. It is important to emphasize the role of parents. If the goals mentioned above are achieved, parents will also be motivated to encourage their children to use the developed proposal. The use of the developed proposals may require that they be conducted guided, accompanied or alone. For this reason, our proposal is designed as a game-based scheme that uses computer games. The fact that the design and development of these computer games must be undertaken by teachers can be a major impediment. These games need to be adapted to the context of the specific group of students and cannot be commercial products if the students' motivation is to be preserved. Game-based learning can be broadly defined as the use of games at any stage of the learning process to enhance both learning activities and learning outcomes (Trajkovik et al. [37]). The design of these resources must be planned based on several factors, some of which are very volatile (for example, the interests of the students, their maturity, etc.). These are aspects that evolve and change within short periods of time. In other words, the use of a game-based approach does not guarantee success, as demonstrated, for example, by Kablan [38] and Sayan [39].

### 5.2. Teachers and Computer Games Development

As mentioned above, one of the goals when designing our proposal was the possibility of adapting the scheme while maintaining its effectiveness and without incurring high development costs. The proposal presented in this work is based on the development of computer games that can be used both inside and outside the classroom by preschool students. At other levels of education and in other areas of study, teachers may have acquired competencies that allow for the development of this type of resources, but it is clear that at preschool level, the set of relevant competencies required by teachers does not include skills related to software development. The essential competences required at this level, as indicated by McDonald Connor et al. [40], are related to pedagogical and psychological factors. For example, Brophy [41], Fraser [42], Stockard and Mayberry [43] have highlighted the relationships between student outcomes and classroom variables such as praise by the teacher, the amount and pace of instruction and the expectations of the teacher.

Teachers, and especially preschool teachers, should not be required to have computer science skills to the level needed to develop computer games. However, they are trained in the use of ICT tools that allow them to use previously developed resources. As mentioned above, if these resources are not adaptable, it will be very difficult for them to be effective, and if this adaptability involves a high development cost, the resources will not be useful.

In addition, it is advisable to have a knowledge of computational thinking (CT). CT skills undoubtedly help not only in the use of ICT tools, but also in understanding how they work. A thorough knowledge and understanding not only of the visible functions, but also of the non-visible behavior of these tools will allow for an understanding of the capabilities offered by these tools. As noted by [44], there have been increasing efforts to integrate CT into curricula across all educational levels, and positive associations have been observed with complex numerical, verbal reasoning and non-verbal reasoning abilities.

In the second part of the game, the learning objective is changed. Figure 3g,h show that the learning objective now involves a knowledge of insects and, hence, also the learning of more words. In the last two screens, shown in Figure 3i,j, visual acuity is developed by asking the learner to match the drawings of some insects with their shadows. All the screens can easily be modified; for example, in the last screen, parts of the shadows are eliminated to complicate the process. Adding shadows that are more difficult to discern can also complicate the process.

### *5.3. Resource Development*

We have presented examples of two of the available resources, which are computer games accessible through a web browser. These can be developed without knowing a programming language. In this section, we will describe the development process using the options provided by the selected web tool, Genially https://genial.ly/ (accessed on 3 December 2022), which is a key aspect of this proposal. Genially is a tool in the form of a web service for creating interactive content, such as the resources presented in this paper, presentations, infographics, etc. There is a community of users creating an ecosystem around this platform. As expected, this ecosystem provides both free and paid resources, but it should be pointed out that the large number of free available resources enables large projects to be carried out, and that the use of these resources serves to accelerate development. However, they are not imperative.

Once conceptualization is complete and both the learning objectives and the type of resource to be developed have been determined, one of the most important decisions is the level of interactivity desired or required from the resource. Note that some forms of interactivity can be added during the design process, while others need to be considered in the early stages of development. The most significant steps in the design of the first computer game are illustrated in Figure 4, and are briefly described below.

The development of any resource begins with a decision or need to start development, which may involve a blank template, a template without interactivity or a template with interactivity. The difference between working without a template (blank resource) and a template without interactivity is minimal, since in this case the template simply provides the background image for the resource. Many templates without interactivity can be found among the free resources offered by the service provider. This was the case for our resource based on the game of the goose, for which development began using the template shown in Figure 4a. Our desired learning objectives did not require automatic movement of the token from one square to another without the need for player intervention based on the random result of rolling the die. Instead, the player was required to move the token interactively in order to achieve objectives related to a knowledge of numbers. If automatic movement of the token is required, we would highly recommend using a template that already includes this interactivity. As mentioned above, there is a fast-growing ecosystem around this service, which provides free resources with great potential and versatility. Some outstanding resources can be found, for example, at https://sandboxeducacion.es/recursos-genially (accessed on 3 December 2022), which offers resources specifically designed for Genially; however, there are many others, such as those provided by https://www.canva.com/ (accessed on 3 December 2022) or https://www.flaticon.com/ (accessed on 3 December 2022).


**Figure 4.** Development of the game of the goose. (**a**) Template. (**b**) Addition of a static object. (**c**) Addition of an interactive die. (**d**) Standard interactivity settings. (**e**) Configuration of animated objects. (**f**) Addition of multiple objects. (**g**) Addition of an interactive element. (**h**) Addition of an interactive external object. (**i**) Functionality test in the development phase. (**j**) Final functionality testing.

One typical task is the addition of the objects that will compose the game. Figure 4b shows the insertion of the tiger image that identifies the group, which may be stored locally, in the cloud or inserted via a copy–paste process. In this game, the tiger image is not a simple one:;it conceals the rules of the game, which are shown when the learner interacts with the image. The type of interaction can be configured as shown in Figure 4c. The inserted objects may not be movable, such as the image of the tiger, or they may be allowed to move, such as the players' tokens shown in Figure 4d.

The fact that an object cannot be moved by a player does not imply that it is a static object: on the contrary, animations or movements can be configured, as can be seen in Figure 4e, which shows the animation of a purple arrow. Another step is to insert the appropriate images into different boxes according to the learning objectives, as shown in Figure 4f. These images can be easily changed in later versions of the game. There are many types of objects that can be inserted into the game, including a large number of interactive elements such as circles with a star inside, which are one type of configurable interactive element, as shown in Figure 4g. The number of interactive elements that can be added is not limited to those provided by the development software; external interactive elements can also be added, such as the dice shown in Figure 4h, which are available from the ecosystem related to this development platform.

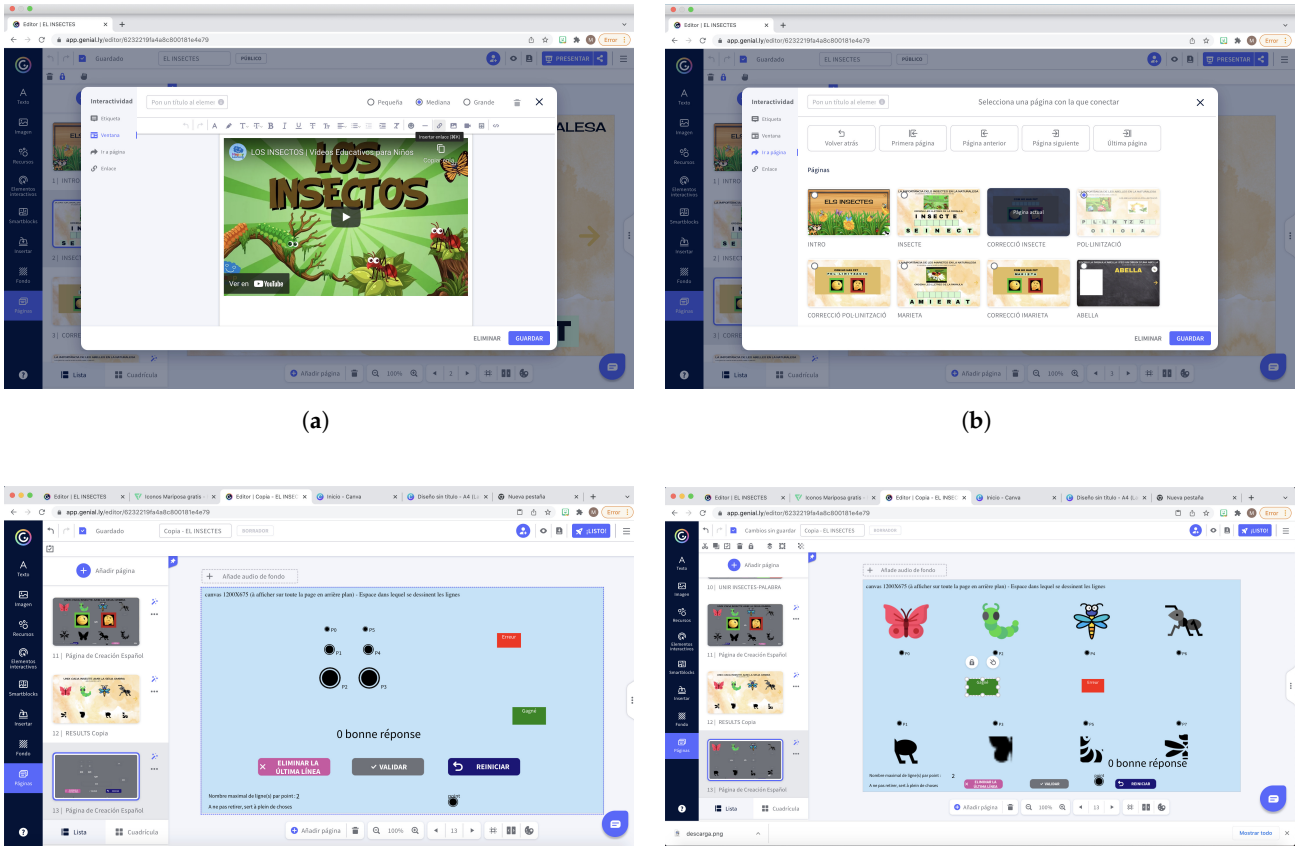
As it is being developed, the game can be tested in order to correct errors, to debug the functionality, as shown in Figure 4i, or to change the learning objectives, as shown in Figure 4j.

It is important that once the initial version has been developed, it will be a live resource that evolves with the students' abilities. We must also allow for the development of specific versions, for example, for students with different abilities. This will allow motivation to be maintained, but will only be viable if it does not impose high costs in terms of development time.

It is important to point out that this motivation relates to both the students and their parents. Motivation of students is achieved by designing a resource that is developed for the small group to which they belong, as they are the protagonists. The ability to keep these resources alive with low development costs also allows us to adapt them according to feedback received from their use in the classroom. This aspect is very important in order to maintain motivation, since any discouraging aspects of the resource can be removed.

Motivation of parents, which is equally important to that of students at an early age, is achieved in various ways. Firstly, we eliminate tasks such as worksheets photocopied on paper, which are often of low quality and are not designed for the specific objectives that we aim to address. Secondly, we remove homework altogether and instead offer a game that allows learners to work on these goals by playing at home rather than doing homework. Finally, parents can rest assured that this game is specially designed and developed for use by children. Parents can therefore avoid the arduous task of having to search for and analyze supposedly educational computer games. These games are safe for children, whether used alone or in a group.

Unlike the previous example, this second game was started from a blank template, and all the screens analogous to those shown in Figure 3a–f. In Figure 5a, were developed from scratch. The multiple screens developed can be seen on the left side. A new type of interaction is added and associated with the image; this interactivity allows a short video to be played automatically when an image is selected. These videos are used to reinforce the knowledge seen in class. They also allow parents to know the subjects that their children are learning. These linked resources can be hosted on the platform itself or they can be external resources. Different types of resources can be linked (such as videos and web pages).




(**a**) (**b**)

(**c**) (**d**)

**Figure 5.** Development of the insects game. (**a**) Configuration of an interactive video. (**b**) Configuration of the screen used for a manual correctness check. (**c**) Interactive template. (**d**) Screen design based on an interactive template.

For this game, we developed two different ways of detecting whether or not an answer is correct. The first is manual, and can be used when the game is supervised by parents. Figure 5b shows the design of the screen used to check the correctness manually, which was developed from a blank template as mentioned above.

The second part of the game, shown in Figures 5g–j, includes more complex interactivity. This allows for the linking of objects and automatic correction, among other features. Our design started with a template that included these interactivities; this template is shown in Figure 5c, and is very different from the final design shown in Figures 5g–j. Objects needed to be moved around the template, added and replicated, as shown in Figure 5d, to form the final design.

It is worth mentioning that we used interactivity to analyze the use of these resources at home without the need for a survey of parents, which may not have been reliable. Part of the linked information was not provided in the classroom, which allowed us to analyze whether the students acquired this information by using the resource at home. The conclusion was that use of resources in the home was achieved by 100% of the students in the groups analyzed. Moreover, although some of the resources were conceived for use exclusively in the classroom, it became necessary to provide them to families, due to insistent requests from the students to be able to use them at home with their families.

## 6. Discussion

This work proposes a working methodology that should be considered in the future for the development of teaching-learning activities. Education 4.0 forces the student to become the protagonist of his learning process, and this cannot always be achieved with pre-designed resources that must to be adapted to the largest possible number of users. Our

proposal marks a path of future research and development to develop learning development systems, not just learning systems. This proposal addresses the main disadvantages of online early childhood education that have been identified and analyzed in recent studies in the new post-pandemic situation. These disadvantages are mainly related to the limited resources for children at home, technical problems and limited training in online methodology. Therefore, this proposal allows good teaching practices at a high level, the enhancement of digital culture and the involvement of parents in children's activities at home.

## 7. Conclusions

In this paper, a viable, efficient and effective solution is presented to design and develop distance education proposals for students from three to five years old. These resources are designed and developed by teachers without requiring computer skills. It is the teachers who work every day with the students, and thus know the needs of these students, that design the resources according to these needs. Moreover, in this paper, we have presented part of our curricular project in the form of a set of resources based on computer games intended for learners from three to five years old. This proposal has obtained positive recognition from authorities with educational competences in Valencia, a region of Spain. A great deal of positive feedback was also obtained from students, their families and school managers, which motivated the development of new resources. The use of the proposed resources at home was verified as effective in terms of achieving the learning objectives. The platform used here was Genially, which offers a clear example of the success of a start-up that is undergoing constant evolution, with the launch of tools for collaborative work planned in the coming months. We hope that this will further reduce development times by facilitating collaboration among teachers, who also act as developers. Motivation, which is key to learning, is achieved through the personalization allowed by the methodology presented herein, in addition to the correct design of resources with regard to their content and objectives. Work is currently under way to transfer this know-how to the next stage of education (the primary school level of the Spanish educational system), and we are developing resources that can be used at the end of the current stage and at the beginning of the next stage.

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