

## App Per-Q Teponaztli: Innovation for rhythmic music education

## App Per-Q Teponaztli: Innovación para la educación musical rítmica

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### Abstract

The following article presents the Per-Q Teponaztli mobile application as an innovation proposal for music education. Per-Q Teponaztli is a complementary tool of Per-Q, a rhythmic musical training program for children between 7 and 12 years of age implemented in virtual learning environments and based on different rhythmic musical learning methodologies that promote the development of multi-functional skills, and intercultural. The design and implementation process of the application was carried out through the agile SCRUM methodology. Developed for the Android environment, Per-Q Teponaztli consists of a virtual representation of a teponaztli, a percussion instrument originating in the pre-Hispanic period in Mexico. The direct interaction of the instrument in virtual format through a digital device allows for its implementation of gamification dynamics and game elements mediated by technology, favoring the appropriation of multicultural skills and an approach of students to the musical roots and traditions of our country.

**Musical learning mobiles apps, Gamification techniques, Multiculturalism in musical learning, Intercultural environments**

### Resumen

El siguiente artículo presenta la aplicación móvil Per-Q Teponaztli como una propuesta de innovación para la educación musical. Per-Q Teponaztli es una herramienta complementaria de Per-Q, programa de formación musical rítmica para niños de entre 7 y 12 años de edad implementado en ambientes virtuales de aprendizaje y basado en diferentes metodologías de aprendizajes musicales rítmicos que fomentan el desarrollo de competencias multi e interculturales. El proceso de diseño e implementación de la aplicación se realizó a través de la metodología ágil de SCRUM. Desarrollado para el entorno Android, Per-Q Teponaztli consiste en una representación virtual de un teponaztli, instrumento de percusión originario del periodo prehispánico en México. La interacción directa del instrumento en formato virtual a través de un dispositivo digital permite en su implementación dinámicas de gamificación y elementos de juego mediados por la tecnología, favoreciendo la apropiación de competencias multiculturales y un acercamiento de los alumnos a las raíces y tradiciones musicales de nuestro país.

**Apps de educación musical, Técnicas de gamificación, Multiculturalidad en aprendizajes musicales, Ambientes interculturales**

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## Introduction

Per-Q is an online rhythmic music teaching programme for children between 7 and 12 years old, of which a first pilot module will be implemented during the summer of 2022 through the Google Workspace platform. The programme is based on different rhythmic learning methodologies where play and improvisation are common elements, considering its implementation in virtual environments with the mediation of digital tools and Information and Communication Technologies (ICT). The Per-Q programme integrates the product "Per-Q Teponaztli" to generate gamified activities as part of an educational innovation strategy. The concept of gamification is defined as "the use of game elements and game design techniques in non-game content" (Werbach and Hunter, 2013) and has been integrated as part of new trends in educational techniques, having as one of its main objectives the acquisition of knowledge through fun and enjoyable learning experiences, leading students to enjoy and become more involved in their learning process.

The teponaztli is a percussion instrument originating from pre-Hispanic Mexico (the instrument, as it is known, dates from the Mesoamerican post-classical period, between 800 and 1000 AD. - 1521 AD). Mexico has a great musical cultural wealth and the programme is a means of bringing new generations closer to its culture. The virtual representation of a musical instrument allows users to learn about and interact with instruments that may be considered unconventional and to experience their performance in an accessible way.

One of the main methodologies of the project is the Dum-Dum Programme by Santiago Pérez- Aldeguer, which, in addition to having game dynamics, has among its objectives the development of multi- and intercultural competences in students. For Pérez- Aldeguer (2014) inclusive education is "the set of principles that ensure that the student, regardless of their characteristics, is a valuable person". Multiculturalism refers to the presence of several cultures in the same society, and "assuming it means recognising the right to difference as an educational and social enrichment" (Imbernón, 2000).

From a multicultural approach, music can be used as a pedagogical resource that fosters the acceptance and recognition of cultural diversity.

Another of the project's core methodologies is "How to play", a series of rhythmic learning methods for percussion created by Alan Dworsky. Among the methods is Slap Happy, which focuses on rhythmic musical performance with body parts and allows students to experience playing world rhythms without the need to acquire an instrument. While children are learning the rhythms, they will be developing coordination, concentration and cooperation (Dworsky, 2002).

The basis of the methodology is the performance and creation of rhythms without the need for a musical instrument. Rhythm can be executed by body movements or even everyday objects can be used to produce rhythms or even to make one's own instrument. The Slap Happy method provides accessibility options that can be adopted as part of the programme's philosophy: there are no limits to the rhythms that can be played, they can be made with one's own body, with everyday objects and with free downloadable digital applications.

The development of specialised music software has gone hand in hand with the evolution of digital technology. The video game format has given these music creation and production tools the entertainment element of the game itself and the different interaction dynamics that support the concept of gamification. According to Miller (2013), these games have made it possible to generate new approaches to aspects such as composition, performance, pedagogy and musical appreciation, which has contributed to the development of creativity and entrepreneurship.

Gamification as an educational technique is based on different theories that respond to the way in which people interact when they are involved in a game experience. The theories of motivation, self-determination and goal achievement help us to understand what motivates the participants of a game in their interest to achieve objectives and to be participants in an activity where competition is implicit.

The behavioural paradigm is present in the dynamics of video games and justifies many of the characteristics of gamification techniques. Skinner's behavioural theory establishes the term reinforcement, which refers to the reward for a certain behaviour (Hernández and Mateos, 2021). The stimulus-response factor is reflected in gamified activities with the establishment of measurable and observable objectives.

Another theory associated with gamification and present in the application is cognitivism, which "emphasises what happens in the learner's mind when learning happens" (Ahmad et al, 2019, p. 3). The Per-Q programme to which the app belongs is aimed at children between the ages of 7 and 12, which corresponds to the stage of concrete operations established in Jean Piaget's theory of cognitive development: from these ages onwards, symbols are manipulated logically and systematically, connecting to concrete objects (Ibidem, p. 4).

For Piaget (2016) "concrete operations constitute the transition between action and more general logical structures involving combinatorics and a "group" structure. Classification and seriation allow an understanding of the order of rhythm, both in the steps to execute it and to structure it. The notion of numbers from the perspective of seriation and the understanding of space, time and speed allow the rhythmic sense to be captured not only by repetition, and where the visual representation helps as a reference to develop a rhythmic musical idea.

Within the dynamics of use of the application and its gamification elements, constructivism is present, which emphasises that students learn by constructing knowledge and meaning based on their experience (Schunk, 2012). The subject constructs knowledge of reality, since this cannot be known in itself, but through the cognitive mechanisms available to them, mechanisms which, in turn, allow transformations of that same reality (Araya, et al, 2007). Students are active in their own learning processes; it is not just about following instructions and understanding them, it is also about developing learning through experience and experimentation.

The development of the mobile application was carried out using the agile SCRUM methodology, which allowed revisions, adjustments and implementations to be made with each of the actors, including music teachers, software developers, graphic designers and editors.

This application allows to generate actions to bring children closer to the cultural features of Mexico through gamification and graphic and musical elements that are attractive to them, generating through the game the interest and motivation to learn with the use of technological tools.

### **Methodology**

The development of the project from the conceptual level began in 2020 through a research-intervention project in the postgraduate course in Learning Management in Learning Environments of the Virtual University System of the University of Guadalajara.

The design and development of Per-Q Teponaztli is based on applications that represent musical instruments virtually. Regarding the percussion instruments section, there is a wide variety of applications such as Drum Kit (drums) or Shakers (maracas and minor percussions) where by means of touch contact with the screen or the movement of the device itself, the simulation of playing the instrument is produced. There are also percussion applications from different parts of the world such as Djembe Pad, Taiko Sounds or TimbalApp, but so far no application has been developed for a percussion instrument originating from pre-Hispanic Mexico.

The recognition and identification of the needs, the problems presented, the cause and effect relationship, as well as the analysis process derived from the interpretation of the data, made it possible to establish the lines of action and the work plan for the development of the Per-Q Teponaztli mobile application as an element that integrates the Per-Q programme and that, through gamification, aims to develop rhythmic skills, but also to promote a cultural approach.

The technological development was carried out during two semesters between 2021 and 2022, starting with the determination of the SCRUM development methodology for its implementation, considering the elements of change and the multidisciplinary team composed of software developers, music professionals, graphic designers and editors.

This development methodology establishes a fundamental base that integrates partial or scaled deliveries in a continuous way, allowing the production process to be carried out in a more agile and rapid way. Within this methodology there are three profiles or roles with specific responsibilities that make up the work team during the development of the project: the project owner, who establishes, defines and guides the general objective of the project, as well as the specific ones, and is the one who generates the control, verification and follow-up actions of all the project activities;

There is also the SCRUM expert (SCRUM Master) who foresees, controls and solves the risks and problems that arise during the entire production and development cycle with all the members of the work team, and finally there are all the members of the SCRUM team, who are the rest of the people who collaborate in the activities and moments of the development and implementation. This methodology, according to DIMES (2015), establishes the development of activities and work in small or short iterations or cycles, which are also known as Sprints, which allows to have products or functionalities, thus being the ideal methodology for the development of projects or incremental solutions in the creation of solutions where requirements may undergo frequent changes, this implementation integrated the phases of analysis, design, development and testing.

### Analysis

This is the initial phase of the development process and consisted of the creation of the product stack (Product Backlog), a fundamental document that integrates the information collected for its analysis, which was classified and categorised, thus allowing the establishment of the requirements that comply with the functionalities and tasks to be carried out.

The data collection was carried out, first, through interviews with various professionals in music pedagogy on the use of digital technologies in music teaching and the implementation of the established rhythmic methodologies. Likewise, the necessary parameters were defined for the conceptual development of the functionalities that should be present in the solution from the user's perspective. Subsequently, working sessions were held with the development team, which contributed to the conceptualisation of the functionalities from the system's perspective, and with this, the functional and non-functional requirements of the project were specified.

The requirements specification was based on the template of the IEEE Std 830-1998 standard of the Institute of Electrical and Electronics Engineers (IEEE, 1998). From this document, the definition of the product perspective and its functionality was proposed, in such a way that user characteristics, assumptions, restrictions and dependencies were determined, as well as the possible evolution of the project. The following is a description of some specific requirements of the ERS:

<b>Requirement number</b>	R1.02		
<b>Requirement name</b>	Open start menu		
<b>Type</b>	<input checked="" type="checkbox"/> Requirement	<input type="checkbox"/> Restriction	
<b>Source of the requirement</b>	Interview 12/09/2021, log 02		
<b>Priority of the requirement</b>	<input checked="" type="checkbox"/> High/Essential	<input type="checkbox"/> Medium/Wanted	<input type="checkbox"/> Low

<b>Requirement number</b>	R1.09		
<b>Requirement name</b>	Load instrument images		
<b>Type</b>	<input checked="" type="checkbox"/> Requirement	<input type="checkbox"/> Restriction	
<b>Source of the requirement</b>	Interview 12/09/2021, log 05		
<b>Priority of the requirement</b>	<input checked="" type="checkbox"/> High/Essential	<input type="checkbox"/> Medium/Wanted	<input type="checkbox"/> Low

<b>Requirement number</b>	R3.07		
<b>Requirement name</b>	Playing the instrument's sounds		
<b>Type</b>	<input checked="" type="checkbox"/> Requirement	<input type="checkbox"/> Restriction	
<b>Source of the requirement</b>	Interview 18/09/2021, log 03		
<b>Priority of the requirement</b>	<input checked="" type="checkbox"/> High/Essential	<input type="checkbox"/> Medium/Wanted	<input type="checkbox"/> Low

**Table 1** Specification of requirements  
Own Elaboration

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After defining this document, the Sprint Backlog was drawn up, in which the actions, times and resources to be carried out were defined. In addition to the assignment of tasks and the SCRUM team responsible for monitoring, the times and execution of each task were defined very precisely, for which Gantt and PERT charts were developed.

The specification of the Sprint provides the necessary elements to carry out the integration tests under an incremental model, in addition to the development of the meetings (Daily SCRUM), which were scheduled on a weekly basis according to the schedule of each of the team members. In this way it is possible to integrate the management of the risks detected in the development process.

### Design and development

This phase includes the architectural and semantic design of the metadata, as well as the generation of all the audiovisual material required by the application in accordance with the established requirements and functionalities.

The development determined by functionalities and established for an incremental model allowed the definition of the system modules that are proposed from the Unified Modelling Language (UML) for the static and dynamic modelling of the system, considering the determination of the class or component diagram in which the elements that make up the solution were determined, considering attributes, methods and relationships, specifically in the elements that establish communication and send-receive messages or objects. In the same way, the design of the use cases was developed from a graphic model, with special emphasis on the interactions and triggers through the actors, to the definition of the processes, and the links that exist between the entities.

The development of the audiovisual material began with the graphic design of the teponaztli, which corresponds to the image and visual identity of the Per-Q programme, aimed at a children's audience, so the graphic line was at all times developed under a design criterion of material for children, presented below:



**Figure 1** Design of teponaztli  
*Own Elaboration*

In the same way and congruent with the functionality of the application with respect to the real or physical instrument, the recording of the real sounds of the instrument was made, reproducing the notes of G (left reed) and C (right reed). A third sound is reproduced in the application in the lower central part, represented in the drawing as a Q carved in wood. Its sound is the note of G at a higher pitch than the reeds. The following picture shows the description of the notes in the design:



**Figure 2** Sounds of teponaztli  
*Own Elaboration*

The application development process was carried out using Unity, which is considered to be a video game engine, also known as a game engine, which is a development environment that has a series of programming routines for the design, creation and operation of an interactive environment. Unity is cross-platform and allows development for operating systems such as Windows, Mac OS and Linux. The development environment with the project that was created is shown below:



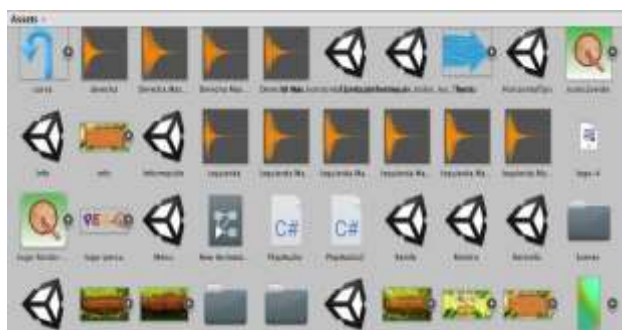
**Figure 3** Project environment  
*Prepared by the author*

The development of the solution required the configuration in specific spaces for the functionality of the game. Below is the image of the allocation of sounds in delimited spaces, corresponding to the tabs and the engraving of the letter Q at the bottom centre:



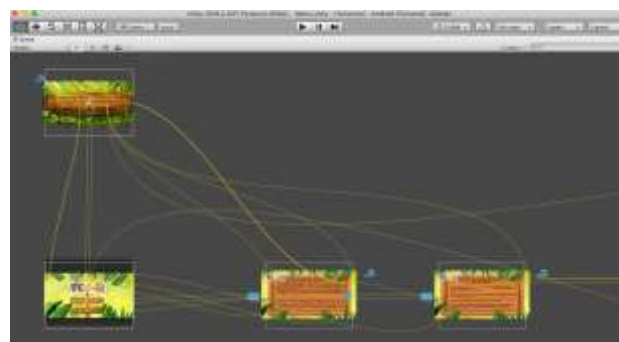
**Figure 4** Allocation of sounds in delimited spaces  
*Own Elaboration*

The construction of the application and the combination of the programmed actions or routines associated with multimedia resources made it possible to have a catalogue of resources for the development of the project. Below are the assets (resources) most used for the development of the project, which were mainly audio files .wav (recorded sounds of teponaztli) and image files .jpg (images of the app), which are shown in the following image:



**Figure 5** Project resources  
*Own Elaboration*

The design and construction of the application based on the user experience and the gamification approach allowed to establish that routine or route of the scenes of the application, thus generating a storyboard or script that links and ties together all the scenarios and modules of the application. The following image shows the linking of the scenes of the application:



**Figure 6** Scenes from the application  
*Prepared by the authors*

## Testing

At the end of the development of the application, the installation and testing process applied to the functionality of the system was carried out. This was carried out by means of a verification tool for the review and processes that will validate the technical (functionality), visual (graphic design and multimedia) and integration (linking scenes) aspects. The icon of the application installed on a mobile device is shown below:



**Figure 7** Icon of the application  
*Own Elaboration*

The start of the application as the initial pop-up window in the start-up process contains the visual identification of the project, which is presented as the application start-up window shown below:



Figure 8 Start-up design of the application  
Own Elaboration

Once the process has started and the player is ready to start the game, the image or menu is loaded from which the user controls the operation of the instrument. This main menu has two options: the information section, which describes the instrument and its characteristics in detail, and the to play section, which presents the image of the instrument with the aforementioned characteristics. It is from here that the user interacts with the virtual instrument by touching the screen of the mobile device with his fingers. The screen is presented below:



Figure 9 Menu of the application  
Own Elaboration

The information section is made up of 3 windows or scenes that have the purpose of sharing information about the origin and characteristics of the instrument and in one of the windows the bibliographical references are presented. The following images correspond to the scenes that make up that section:

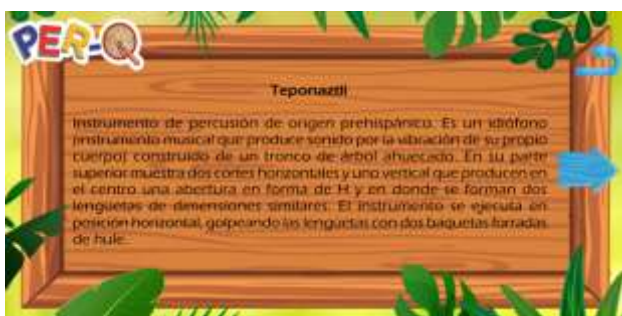


Figure 10 Information scene 1  
Own Elaboration



Figure 11 Information scene 2  
Own Elaboration



Figure 12 Information scene 3, bibliographical references  
Own Elaboration

The app has features of behaviourism in its implementation: the instruction and tracking of its outcomes, also present in a variety of video games, as well as the idea of both classical conditioning, which states that behaviours can be conditioned by providing repeated stimuli, and operant conditioning, behaviours are reinforced by the rewarded response (Ahmad et al, 2019, p. 3).

The element of motivation and goal achievement is identified, which also expands the dimensions of the outcome: an intangible reward or an intrinsic reward, where "the individual does not look at the consequences, he acts for the action itself" (Borrás, 2015), which in this case is learning about a musical instrument that he probably does not know and the possibility of playing and creating rhythms through the application.

From the pedagogical perspective of constructivism, the learning process is active. The user's experience of interacting directly with the application from their device allows them to get to know a different instrument, to know what its shape is like and how it sounds. The interaction allows them to experiment with its timbres and play with the rhythmic possibilities, which leads to improvisation and creative development.

**Results**

During the first months of 2022, the initial implementation tests were carried out, which allowed us to detect areas of improvement in the application and to make the corresponding adaptations to ensure its functionalities.

The first tests correspond to a review of the functionality of the application from a technological perspective. The application was installed on various smartphones with an Android operating system by the project team. The application is successfully installed on the selected operating system, can be opened and effectively plays both the scene sequences and all the corresponding images and sounds. To reinforce the review of the app's functionality, support was requested from people external to the product development to install the application on their Android devices. The results were the same as in the previous tests.

Likewise, after the technical review, it was necessary to evaluate the implementation of the app in the target audience and thus identify the fulfilment of the objectives established with a focus on gamification and the achievement of multicultural competences, for which an open questionnaire was designed as an evaluation instrument that was applied in person to children in the Guadalajara Metropolitan Area.

The results show conclusive information about the implementation of the application and the knowledge acquired from the approach of the gamification technique and the development of multicultural competences. 100% of the respondents considered the application to be fun and to simulate a gaming experience. The vast majority showed great interest in the teponaztli instrument, finding it fun and interesting to learn about old or "unfashionable" instruments. Although more than half of the participants responded in the survey that their main learning experience was learning about the instrument, there were also responses regarding the use of the app to generate and play rhythms. The use of the app by the participating children also aroused in them a curiosity to learn more about old instruments and an interest in acquiring and downloading the app.

With the results obtained in terms of the technological approach and the implementation of the app as a tool for gamified activities, Per-Q Teponaztli was registered in the Android download shops, specifically in the Play Store platform. The application will be available for free download in the second half of 2022, coinciding with the implementation period of the first module of the Per-Q programme..

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**Conclusions**

Through the SCRUM methodology and its respective tests in the development of the app, as well as in the application of the functionality evaluation instrument, it can be determined that the Per-Q Teponaztli application has a viable use as a digital didactic tool.

The SCRUM methodology allowed for an agile and orderly development process. The determination of the roles in the work team together with a work plan monitored from a punctual follow-up achieved a professional and systematised process, where objectives were met based on established dates.

The objective of virtually representing the teponaztli instrument was successfully achieved by being able to replicate its aesthetic and acoustic characteristics through images and sounds. Based on the project's image identity and the target audience, the design of the drawing of the instrument is kept within the same graphic line without leaving aside the physical qualities of a real teponaztli.



From a review of functionality, the tests carried out in the process give evidence of an application developed adequately for its operation: the app is easy to install on the devices for which it is programmed, its menus and scenes open smoothly and present an interface that is easy to navigate. On the other hand, the performance of the instrument in its virtual interaction is appropriate to the characteristics of the instrument both in its timbres and its sound body, and the app responds to touch in the right places and with the real sounds of a teponaztli.

The informative part within the app is presented as an added section that complements the learning and experience of knowing and interacting with the percussion instrument with information about its characteristics and origins, so that the complementary section reinforces the objective of developing multi- and intercultural competences and a complete and documented approach of the users to the musical traditions of our country.

Tests of the use and impact of the application with children demonstrate its effectiveness as an attractive tool for the public and whose characteristics allow for fun, enjoyable and accessible learning dynamics. The application manages to generate a gaming environment, so its use is supported as part of a gamified strategy. From a pedagogical perspective, the use of the app presents in its implementation characteristics of the various paradigms and theories of learning on which gamification is based: the theory of motivation, behavioural theory with the element of reinforcement, cognitivism, reflecting rhythmic learning from concrete operations, seriation and classification, and constructivism where the participant constructs and develops learning through their own experience and action.

On the other hand, the application finds in its implementation aspects of the basic methodologies of the project. Following the philosophy of Slap Happy, Per-Q Teponaztli allows users to make and develop rhythms without the need for musical instruments, which constitutes an innovative proposal where mediation through digital devices is presented as an alternative to achieve musical learning in an accessible way.

In the case of the Dum Dum programme, multicultural competences are present in the use of the application as a tool that fosters cultural identity and as a bridge for new generations to learn about the musical diversity and history of Mexico.

In conclusion, the Per-Q Teponaztli proposal, as a complementary tool to the Per-Q programme, is presented as a viable and appropriate option for the characteristics of the programme and its objectives, as well as the competences implicit in the project. The tests demonstrate the functionality of the app from the technological and pedagogical perspectives, so that it meets the requirements to be released as soon as possible for free download and be available in the implementation of the first module of the programme, in the second half of 2022.

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