

## RESEARCH ARTICLE

# Effects of a gamification proposal in the physical education class on motor development in 3rd and 4th grade students at a private school in Valparaíso—Chile

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## ABSTRACT

As a result of the pandemic caused by the coronavirus, the performance of mass physical activities and face-to-face classes have considerably decreased in the spaces for the stimulation of motor development and, consequently, the levels of physical activity in the school population. The objective of this article is to determine the effect of the implementation of a physical-educational intervention based on gamification in specific and compound motor skills in schoolchildren. The study involved 25 students from a private school of Valparaíso, Chile (12 women and 13 men from third and fourth grade). The test of Gross Motor Development Second Edition (TGMD-2) was applied to measure motor development level on students. As a function of the 12-week intervention, motor development was improved according to the Wilcoxon test with a significance of  $p = 0.019$  in locomotion,  $p = 0.013$  in manipulation and  $p = 0.006$  in total motor development. Based on the results, it was concluded that a 12-week intervention based on the gamification method can improve the motor development of students in this age range.

**Keywords:** gamification; motor development; physical activity

## 1. Introduction

Recently, in the educational field there have been several changes produced mainly by the growth and development of technology, which has led education professionals to change traditional methodologies, strategies or techniques, innovating with new ideas for their professional work<sup>[1,2]</sup> and having to incorporate information and communication technologies (ICT's) in their classes<sup>[3]</sup>. In this sense, gamification has made its presence felt in recent years as an alternative to traditional education<sup>[4,5]</sup>. This concept was born from the idea of complementing the dynamics of video games through any medium, whether digital or non-digital, to create playful interactions in different contexts, which has also been widely used for marketing strategies of large companies<sup>[6]</sup>. However, the use of gamification in education is very recent, understood as the use of game elements to motivate students<sup>[7-11]</sup>, involve them in their learning process<sup>[9,12]</sup> and increase their participation

### ARTICLE INFO

Received: 31 July May 2023 | Accepted: 8 November 2023 | Available online: 22 December 2023

### CITATION

Morales F, Sobarzo C, Almonacid JH, Herrera JP. Effects of a gamification proposal in the physical education class on motor development in 3rd and 4th grade students at a private school in Valparaíso—Chile. *Environment and Social Psychology* 2024; 9(2): 1952. doi: 10.54517/esp.v9i2.1952

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and engagement in classes<sup>[9-11]</sup>. In this way, students can also be favored in their academic performance<sup>[8,9]</sup>. This concept is considered not only a method, but also a technique and a strategy at the same time<sup>[13]</sup>.

According to the above, gamification in an educational context could be seen as a way of transforming into playful something that was not playful before in order to motivate and encourage student learning<sup>[7]</sup>, making the game the center of learning<sup>[14]</sup>. There are two models when it comes to gamification in education. The first one is the points-badges-leaderboards (PBL) and is used with rewards and punishments according to the behavior of each student. On the other hand, the MDA model is based on more mechanical aspects, with rules and logic, with dynamic results<sup>[15]</sup>. Specifically, in physical education, gamification is understood as the design of motor experiences that provoke playful learning experiences in the student, using psychological aspects of the game as an essential element of the process<sup>[16]</sup> and also helping to improve attitudinal aspects<sup>[17,18]</sup>. In this context, gamification improves the predisposition of students towards classes, along with creating an interest in the practice of physical activity<sup>[14,17,19]</sup>, being that according to the Chilean Report Card on Physical Activity of Children and Adolescents<sup>[20]</sup>, the percentage of Chilean children who meet the recommendations of physical activity is low, also taking into account that currently the World Health Organization<sup>[21]</sup> recommends an average of 60 min of physical activity per day (at least three days a week).

The use of gamification in physical education class planning not only makes students interested in practicing physical activity, but also improves their motor development<sup>[22]</sup>, variables that are closely related<sup>[23-27]</sup>. Motor development is considered a process of change in motor behavior, caused by the interaction between heredity and the environment<sup>[28,29]</sup>. It is a continuous lifelong change based on the interaction of maturation, previous experiences, and new motor activities<sup>[30]</sup>. Within motor development is the development of fundamental motor skills which begins from the first years of age, through the acquisition of locomotor skills, object manipulation and stability<sup>[27,31,32]</sup>, before becoming a central pillar of education<sup>[33]</sup>. Therefore, motor skills play a fundamental role in the foundation of a lifelong active lifestyle and infancy is considered a critical time for the development of motor skills<sup>[27,34,35]</sup>.

Given the above information, it is of utmost relevance that educational communities consider gamification as an alternative to improve the levels of motor development and involvement in the practice of physical activity of their students, thinking about how useful this methodology was during the COVID-19 pandemic<sup>[36]</sup> and also that we are in post pandemic times and students are even more involved with technology. Specifically in Chile, there is not much evidence that relates the variables gamification and motor development, so its study in our region becomes a necessity. Therefore, the objective of this study is to determine the effect of gamification in the physical education class on the motor development of third and fourth grade students in a school in the city of Valparaíso, Chile.

## **2. Materials and methods**

### **2.1. Study design**

This study is a quasi-experimental study with a quantitative approach<sup>[37]</sup>. In addition, there is no control group associated with the development of this study. The intervention lasted 12 weeks. Each session lasted 60 minutes, with a structure that incorporated a beginning, a development, and a closing. The sessions were carried out once a week, on Wednesdays during the timetable corresponding to the physical education subject. Each session was in charge of the person responsible for the intervention, the physical education teacher of the educational establishment. For the development of the sessions, basketballs, volleyballs, handballs and soccer balls, tennis balls, tennis rackets, sponge balls, sponge sticks, cones, lentils, hurdles, sticks, hoops, mats, bibs, beams and coordination ladders were used. Gamification was used as a method, a process that makes contexts that are not playful<sup>[6]</sup>, using the main tools of the game<sup>[7]</sup>.

The gamification proposals included the “superheroes challenge”, a three-week experience in which the students had to select, from a list of superheroes indicated by the teacher, the one that most represented them. Once the superheroes were distributed, the teacher of the course presented the following problem: Through motor challenges they must be able to defeat the supervillains. The behavior and good conduct in physical education classes, also allows to get upgrade points of superpowers to defeat the supervillains. Superheroes must overcome the challenges described in **Table 1**.

**Table 1.** Example of gamification proposals.

<b>Name of the challenge</b>	<b>Description of the challenge</b>
Challenge 1: eliminating “Sedentarius”.	The supervillain “Sedentarius” is an evil character who has taken control of the school, not allowing any kind of movement or movement to teachers and children from other grades. To defeat the supervillains, all the superheroes must reach a total of 60 points, which is equal to the energy of the enemy. The superheroes must participate in the 8-bomb game, where the course will be divided into red and blue superheroes. The first team of superheroes to complete 8 passes without the ball being intercepted will score 5 points. The first team to reach 60 points will be the one to defeat “Sedentarius”.
Challenge 2: rock, paper, scissors extra large	Continuing with the division of red and blue superheroes, now the boys and girls must defeat another supervillain named “Inactivus”. For this, each team of superheroes must face each other in the traditional game of rock, paper and scissors, but before reaching this area, each member of the band must overcome a motor course composed of stations: running to an area of hoops, then they must jump on one foot inside a hoop, then they must jump together inside zigzag hoops, then they must carry a tennis ball and move on a balance bench, and finally throw the ball into a basket. Once all the superheroes of the team have reached the obstacle-free zone, they must line up and agree on the figure they will represent bodily (rock, paper or scissors) to participate against the other team of superheroes. To eliminate Inactivus, the team whose members manage to complete the course and then beat the other superhero team by three points in the collective rock-paper-scissors game will defeat the supervillain.
Challenge 3: The 3-stroke dynamite.	The division of red and blue superhero teams continues. Now each team must be able to defeat another supervillain known as “Food-Scrapman”. To defeat this new villain, the individual superheroes must run and place a token of their team’s color inside one of the 9 squares drawn on the ground at a distance of 10 m. To score 1 point, they must form a horizontal or diagonal line with their respective tokens inside each square. As well as once they have moved the tiles, they can move them preventing the other team of superheroes to form a horizontal or diagonal line.

Finally, the team that manages to defeat the most supervillains will receive a badge that credits an upgrade of the superpowers represented by their superhero. Also, the teacher during the development of the 3 challenges considered the behavior in the development of the challenges, so each badge of good behavior also allows to upgrade the superpowers of the superheroes.

## 2.2. Participants

The participants in the present study were 25 children (mean age = 9.48; 13 boys and 12 girls), belonging to the third and fourth grades of the Colegio Internacional de Valparaíso, Chile. The inclusion criteria of the participants were to attend at least 70% of the physical education classes and not to have a pathological health condition that prevented them from physical activity.

The application of the instruments was carried out under the ethical principles of research with human beings indicated in the Declaration of Helsinki<sup>[38]</sup> and had the approval of the bioethics committee of the Research Department of the Pontificia Universidad Católica de Valparaíso (BIOEPUCV-H-456-2021). In addition, the authorities of the educational establishment approved its realization, as well as parents and/or responsible guardians proceeded to sign the informed consent, in which they were provided with background information on the research. Throughout the development of this research as well as while writing this manuscript, we proceeded to avoid practices that violate research ethics<sup>[38]</sup>.

The post hoc sample calculation was performed using the G-Power version 3.1 program. For this purpose, the Wilcoxon or Mann-Whitney, corresponding to the *t*-test family. The sample size was 25 participants. With an alpha of 0.05 and an effect size of 0.1, the power (1-β err prob) was identified as 0.92.

### 2.3. Instruments

To determine the level of motor development, the TGMD-2 test was applied, which has been validated in Chile (38). This test is composed of twelve motor tests divided into two major skills. First, locomotion is evaluated in six tests: (1) running; (2) galloping; (3) object jumping; (4) one-footed jumping; (5) horizontal jumping and (6) lateral displacement; and second, manipulation tests which are: (1) stationary ball striking; (2) stationary bouncing; (3) ball reception; (4) ball striking with the foot; (5) ball throwing over the shoulder and (6) ball rolling. The participants performed two attempts per test and could receive a score from 0 to 2 points. The total motor development of the students was categorized according to the total score obtained and age/sex into seven categories: very poor (<70), poor (70–79), low average (80–89), average (90–110), above average (111–121), superior (121–130) and very superior (>130)<sup>[35,39–41]</sup>.

### 2.4. Recording and analysis of the information

An Excel spreadsheet was used to record the data. SPSS software was used for data analysis. First, descriptive statistics, relative and absolute frequencies were used to establish the level of motor development of the participants, for general motor development, the subtests of locomotion and object control.

Subsequently, the Shapiro-Wilk test ( $n \leq 50$ ) was applied to establish the normality of the data. The results indicate that the data do not have a normal distribution, so the nonparametric Mann Whitney U test was used to compare the effect of the intervention in a pre- and post-test. A confidence level of 5% and 95% error was used, with a  $p$  value equivalent to  $p < 0.05$ .

## 3. Results

The following are the results that show the effect of the gamification-based intervention in the physical education class on the motor development of students in the 4th year of elementary school.

**Table 2** shows the results before and after the intervention. The level of motor development had improvements at the general level, decreasing the students who were in the “very poor” and “poor” levels, when the post-test was performed. As for the “low average” level before the intervention there were no students who reached this level and after the intervention there were four. Finally, no student reached the “average” level before the intervention and only one student did so after the intervention. Although it is possible to see improvements in the general motor performance of the participants and a decrease in the number of students in the very poor and poor categories, as well as an increase in the number of students in the average and above average categories, it is not possible to observe statistically significant differences ( $p = 0.125$ ).

**Table 2.** Level of total motor development pre and post intervention.

Motor development level	Pre intervention N (%)	Post intervention N (%)	$p$ -value <sup>1</sup>
Very poor	19 (76)	15 (60)	0.125
Poor	6 (24)	5 (20)	
Below average	0 (0)	4 (16)	
Average	0 (0)	1 (4)	
About average	0 (0)	0 (0)	
Superior	0 (0)	0 (0)	
Very superior	0 (0)	0 (0)	

<sup>1</sup>: Wilcoxon test; \*:  $p$  value < 0.05.

**Table 3** shows the results of the locomotion test before and after the intervention. An improvement is

evident at the general level, decreasing the “very poor” level by 50%. The “poor”, “low average” and “average” levels increased compared to the beginning of the intervention. However, the results are not statistically significant ( $p = 0.088$ ).

**Table 3.** Motor development level of locomotion pre and post intervention.

Motor development level	Pre intervencion N (%)	Post intervencion N (%)	<i>p</i> -value <sup>1</sup>
very por	12 (48)	6 (24)	0.088
poor	8 (32)	11 (44)	
below average	4 (16)	5 (20)	
average	1 (4)	3 (12)	
about average	0 (0)	0 (0)	
Superior	0 (0)	0 (0)	
Very superior	0 (0)	0 (0)	

<sup>1</sup>: Wilcoxon test; \*: *p* value < 0.05.

**Table 4** shows the results of the object control test before and after the intervention. As with the locomotion test, a drop in the “very poor” level is evident. An improvement in the “poor” level, a maintenance in the “low average” level and an improvement in the “average” level. At the general level there was a great improvement, however, it is not statistically significant ( $p = 0.071$ ).

**Table 4.** Motor development level of object control pre and post intervention.

Motor development level	Pre intervencion N (%)	Post intervencion N (%)	<i>p</i> -value <sup>1</sup>
Very por	17 (68)	10 (40)	,071
Poor	4 (16)	9 (36)	
Below average	3 (12)	3 (12)	
Average	1 (4)	3 (12)	
About average	0 (0)	0 (0)	
Superior	0 (0)	0 (0)	
Very superior	0 (0)	0 (0)	

<sup>1</sup>: Wilcoxon test; \*: *p* value < 0.05.

Finally, when observing **Tables 3** and **4**, it is possible to see that between the pre- and post-test, after the intervention there was a greater decrease of students belonging to the very poor level in the object control subtest. Likewise, it is possible to observe that in the object control subtest there is a greater number of students in the average and above average levels than in the locomotion subtest. Finally, although the statistical difference is not significant in any of the subtests, it is in the object control subtest where it is closer to 0.005, so it is possible to indicate that the effect is greater in the object control subtest than in the locomotion subtest.

## 4. Discussion

The purpose of this study was to determine the effect of gamification in the physical education class on the motor development of third and fourth grade students in a school in the city of Valparaíso, Chile.

The results of the study show an improvement in the motor development levels of third and fourth grade children after having carried out an intervention based on the gamification method. As our results show, a study to determine the impact of gamification on the improvement of fundamental motor skills was carried out in a

fifth-grade primary school. At the beginning of the intervention, the sample was divided into an experimental group ( $n = 24$ ) and a control group ( $n = 24$ ). Athletics was selected as the sport and gamification as the methodology for this intervention, which lasted 14 sessions of 50 min each. The results showed how the experimental group improved their scores to a greater extent compared to the control group under the premise that this methodology enhances learning to a greater extent and, as a consequence, the results<sup>[42]</sup>.

The same occurred with an intervention proposal for first grade classes, based on the well-known series and game “Pókemon”, which, based on the characteristics previously mentioned in this article, aimed, among other things, to work on fundamental motor skills and cooperative work among students. During this intervention, eight physical education sessions were applied, obtaining improvements in the development of fundamental motor skills, as well as improvements in attitudinal and motivational aspects<sup>[43]</sup>.

On the other hand, and in contrast to our study, an intervention aimed at improving the physical abilities of seventh grade students, also through a gamification proposal in physical education classes, was carried out during 10 sessions based on the Fortnite video game. Although the main objective of the intervention was to improve physical abilities and attitudinal aspects, fundamental motor skills were also worked within its sessions. It was concluded that the tools that are part of gamification are quite beneficial to obtain positive results in the physical education class<sup>[44]</sup>.

Another study that also conducted an intervention in physical education sessions based on the gamification method, but for the improvement of fine motor skills, concluded that gamification is a beneficial tool for this variable in the first year of primary school, using, as in our study, a pre-test and post-test, the latter being a self-made rubric. Unlike our study, this one had one parallel of the course as the experimental group and the other parallel as the control group<sup>[45]</sup>.

Evidence shows that gamification seems to be a method that benefits not only the development of fundamental motor skills in primary education, but also motor coordination, motivation and creativity<sup>[46]</sup>, being also beneficial and contextualized to post-pandemic times. Complementing innovation in physical education classes together with the use of ICTs can add a fun component that is advantageous to dynamize the teaching-learning process<sup>[3]</sup>.

An article that studied the methods most used by physical education teachers to develop fundamental motor skills in early education concluded that gamification is used to a lesser extent compared to the game method and the method of multiple intelligences (bodily-kinesthetic), but that it is nevertheless an innovative and attractive tool for the 21st century<sup>[46]</sup>.

Another study, which sought to relate the use of gamification to student motivation, concluded that a physical education program based on this method improved the levels of intrinsic motivation in students compared to the control group<sup>[15]</sup>. In the same way, a study concluded that the use of the gamification method helps with the improvement of motivation and the decrease of disruptive behaviors of their students<sup>[47]</sup>.

Along with gamification, the post-pandemic era brought with it other methodologies that make use of ICTs. Among them are the Exergames, which are generally platforms that aim, through games or dynamic activities, to encourage the practice of physical activity<sup>[48]</sup>. Several studies have been conducted to determine their impact on improving the levels of motor development or motor competence in preschool students, with positive results in each of them<sup>[49-51]</sup>.

A study analyzed the role that technology played during the COVID-19 pandemic, concluding that it was very useful in conducting physical education classes, and that even in the post-pandemic era it continues to be so<sup>[36]</sup>. Similarly, another study mentions the importance of technology during the pandemic in physical

education classes, highlighting that after this episode, we must move into a “new era” with innovative ideas, including technology<sup>[52,53]</sup>.

Recognizing the relevance of gamification for favorable and advantageous teaching-learning processes is of utmost importance during primary education<sup>[44]</sup>. However, unlike marketing and the business world, this method is just emerging in the educational world, so more scientific evidence about this relationship is required<sup>[54,55]</sup>.

Finally, the limitations of this study are presented in the fact of not having an experimental group and a control group in order to make differences and comparisons between the pre- and post-test. Another limitation is that this is a quasi-experimental study and presents a very small sample to be intervened and studied.

## 5. Conclusion

From the results of this study, it is concluded that the application of 12 intervention sessions in physical education classes under the gamification method improves the total motor development, including locomotion and object control of third and fourth grade students. These results help make it clear that this method can be of great use in physical education. These results are very useful, since in Chile there is not much scientific evidence that relates both variables and at international level they have not been related with significant results. Thus, there is a need to continue investigating the relationship between both variables in school environment.

## Author contributions

Conceptualization, FM and JPH; methodology, FM and JPH; software, JPH and JHA; validation, JPH, JHA and CS; formal analysis, FM; investigation, FM; resources, FM; data curation, FM; writing—original draft preparation, FM and CS; writing—review and editing, JPH and JHA; visualization, FM and CS; supervision, JPH and JHA; project administration, JPH; funding acquisition, FM. All authors have read and agreed to the published version of the manuscript.

## Conflict of interest

The authors declare no conflict of interest.

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