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Gamification In Physics Class For Athletes: Concerns And Attitudes For A Positive Sporting Life

Cindy Yineth Marin Olmos[1] , Jaime Duván Reyes Roncancio[2] , Edier Hernán Bustos Velazco[3]

[1]ciyimarin@gmail.com https://orcid.org/0000-0002-5175-4203
Universidad Distrital Francisco José de Caldas
[2]jdreyesr@udistrital.edu.co https://orcid.org/0000-0002-9229-1196
Universidad Distrital Francisco José de Caldas
[3]ehbustosv@udistrital.edu.co https://orcid.org/0000-0003-0072-8598
Universidad Distrital Francisco José de Caldas

ABSTRACT

This article aimed to determine the learning developed by a group of tenth-grade students at a private school in Bogota (Colombia) about Newton's laws, based on the approach of Phenomena-Based Learning (PBL) and using gamification as a teaching strategy. The action research methodology was interpretative and qualitative; for the implementation, the population studied was first characterized by identifying the personality of the type of player; then, the activities were designed considering the dimensions of the PBL; the six levels of the gamified system served as a basis for the collection of information. Subsequently, the news was analyzed, taking as a reference the categories of data analysis: holisticity, contextuality, authenticity, strength, Newton's laws, and gamification, and the data obtained were interpreted using the MAXQDA® program. Finally, the students emphasized that learning can be done in a different and fun way and that the activities motivated them to advance in their education; it was determined that in addition to having the theoretical bases corresponding to their grades around the topic of Newton's laws, they achieved explanations from different areas of their daily knowledge and find value and usefulness to what they have learned.

PALABRAS CLAVE / KEYWORDS Gamification, Phenomenon Based Learning (PBL), Virtual learning, Newton's laws, teaching

Introduction

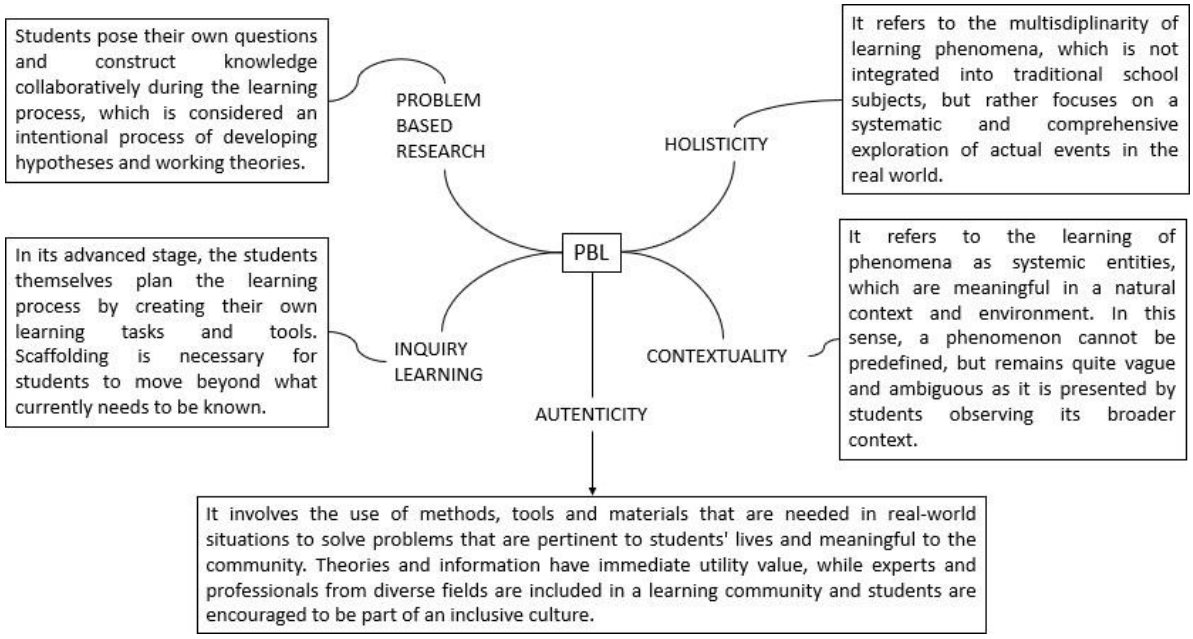
One of the causes of low academic performance in high school students is the lack of motivation toward the school process; according to the study conducted by Villar (2018), family aspects, school curriculum, routine, context, and types of teachers, are some of the factors that influence the lack of interest; not far from this reality is the teaching of science and more specifically the teaching of physics, in which, in most cases, generic school texts with "problems" are used as a guide, as students call it, far from their daily lives and which do not connect them with activities they do in their daily lives. Villar (2018) also exposes the need for a change of curriculum in which there is a constant reflection on the contents, which should be aimed at an effective and meaningful education for students, also invites to change the beliefs of teachers and provide classes with active and interactive methodologies. Therefore, the research proposed a series of engaging activities for students, allowing a connection with their current world, for which gamification and Phenomena Based Learning will be used. These strategies have allowed an immersion in students' experiences and influenced their motivation.

Phenomena-Based Learning (PBL)

Phenomena-based learning is a teaching and learning method in which students learn in an interdisciplinary way through situations of their environment and the present; as indicated by Vilchis and Estrada (2021), it can be the basis

for the development of communication skills, critical thinking, creativity, collaboration, and global vision of the context in students from the first school stage. Symeonidis & Schwarz (2016) express that this approach is based on constructivism and includes socio-cultural learning, progressive learning by inquiry, and problem-based learning; the previous framework provides the necessary tools for the student to be an active subject in their learning process, as Silander (2015a) states, students are seen as active builders of knowledge where information is given because of problem solutions. Figure 1 shows the characteristics of the PBL, which served as the basis for designing the learning activities.

Figure 1. Characteristics of Phenomena-Based Learning. Source: Own elaboration, based on the work of Camacho, D. and Yate, P (2019)



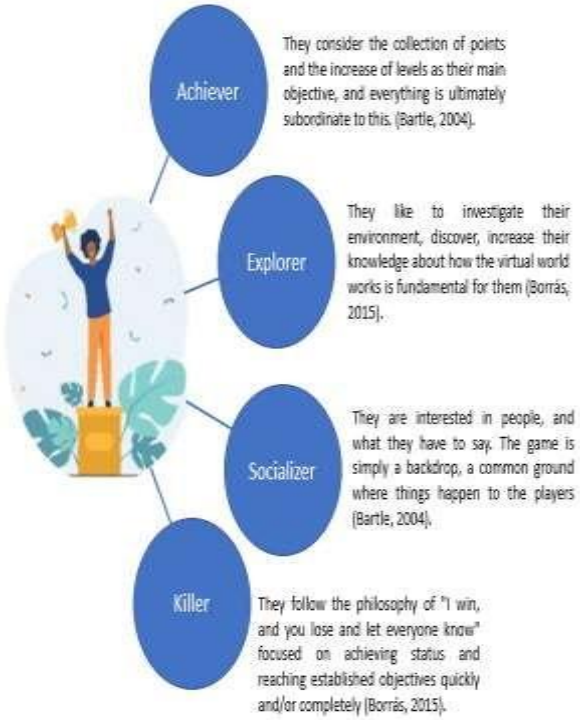
1.2. Gamification

According to Teixes (2014), "the reason for its success lies in the contemporaneity of its approaches because it not only aims to solve problems that affect motivation, but it is also focused on the psychological profiles of students" (p.5); this is because this generation has different characteristics and ways of relating to those that had been seen so far.

Borrás (2015) explains some reasons why gamify, among them are: it activates motivation, allows more meaningful learning, generates commitment, builds student loyalty to the content and tasks, and shows more measurable results, among others. As in any methodology to be implemented, there are advantages and disadvantages. However, it is observed that gamification could bring immediate results in the teaching processes since many students are already immersed in different types of games.

For the development of gamified systems, it is essential to know the target population; that is why Bartle (2004) classifies the population into four personalities that are present in the game these are Achiever, Explorer, Socializer, and Killer, knowing the characteristics of each one makes it possible to customize to a greater extent the experience of students and have the necessary engagement for the viable development of the process. Some characteristics of each of them are:

Figura 2. Características del tipo de jugador. Fuente: Elaboración propia



2. Method

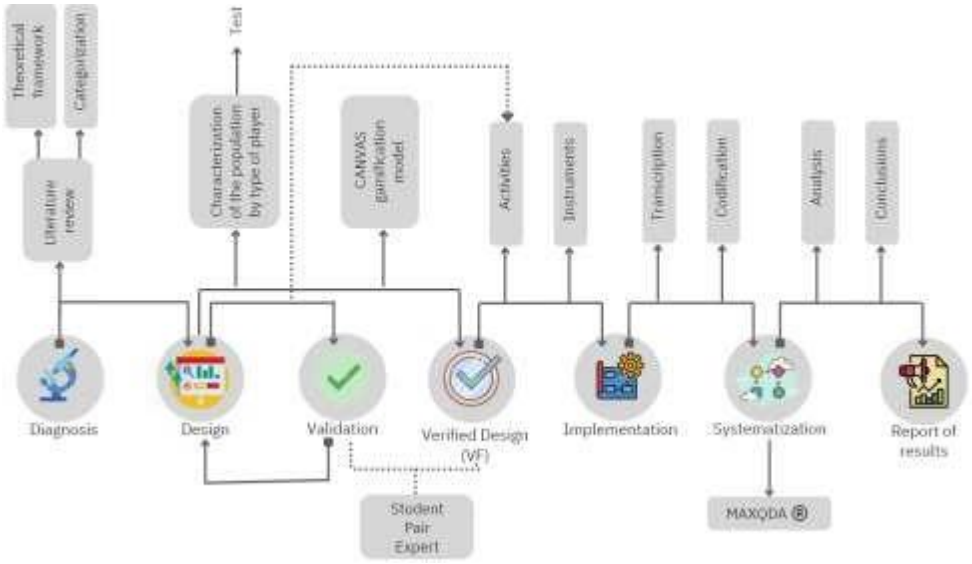
The research was developed with a focus group of tenth-grade students; the sample was chosen in a non-probabilistic and homogeneous way, considering as selection criteria the basic level of academic performance, a low personal organization in the development of educational activities, and participation in extracurricular sports activities. Since the visions, actions, and learning of the students were taken into account, the research was qualitative, with an interpretative cut; as mentioned by Hernández et al. (2014), "we try to make sense of the phenomena according to the meanings that people give them" (p.9), the central point of the research, since we sought to characterize the learning of the students and also to influence in a behavioral change.

The methodological approach is framed in action research (AR), which is pertinent to the collective character implied in the planning and development of research practices. Thus, the students' participation consisted of having the propositional role in the process, and the teacher-researchers participation consisted of being a guide, orienting the whole process.

The methodology was carried out in four phases (Figure 3); in the first phase, a literature review was conducted, considering three thematic axes: Phenomena-Based Learning (PBL), gamification of learning and Newton's laws, the types of players present in the group were

identified through the test designed by Richard Bartle (Innova Talent, 2016), to guide the design of the gamified module with the characteristics found in the group.

Figure 3. Methodological phases of the research. Source: Own elaboration.



In the second phase of design and validation, the typification of the players together with the CANVAS model served as the basis for the creation of the didactic module; six activities were proposed, which corresponded to the six levels that had to be overcome to achieve the learning goals, after the design of the activities were validated with a student, an academic peer, and an expert.

The third phase of implementation was carried out through the campus, supported by the Moodle platform; with the unit's performance, information was collected about the learning obtained by students about Newton's laws, focused on the phenomenon of injuries in athletes.

In the last phase, the categorical system was generated deductively for the information analysis. The set of themes or categorical descriptors was broken down, and finally, the information was systematized and interpreted with the MAXQDA ® qualitative data analysis software. In this sense, the general principles of content analysis (Bardin, 1986; Kripendorf, 1990,2004) were used, mainly from a qualitative semantic approach to relate the terms and statements of the students with the study categories.

3. Results and discussion

After coding and subsequent analysis, the following results were found, classified into three aspects: identification of the type of player, interaction with the gamified unit, and learning related to the categories of analysis: holisticity, contextuality, authenticity, and strength, Newton's laws, and gamification.

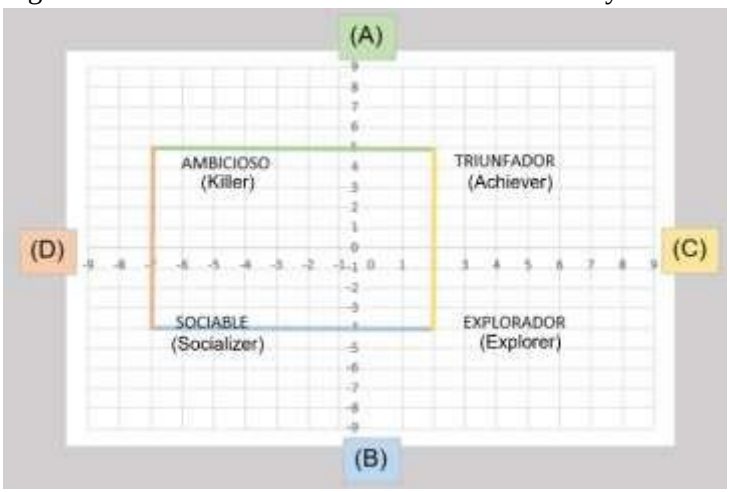
3.1. Personality test of the players present in the group.

After obtaining the data from the test application to the group of students, it was found that the majority tended toward a gamer profile, nine towards the successful profile, three towards the ambitious, one towards the social, and one toward the explorer.

It is essential to mention the importance of the word tendency since, as Bartle (2004) says, all people have characteristics of the four types of players. However, there is an inclination towards one of them. To better orient the above,

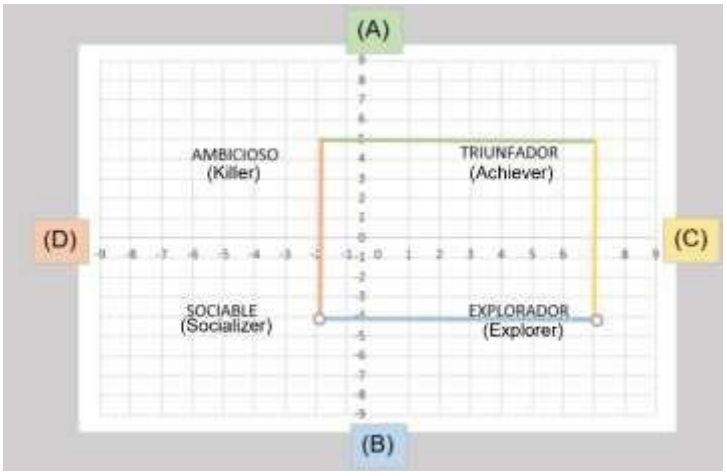
it is necessary to observe Figures 4 and 5, where it is analyzed how the area of the parallelograms is in more significant percentage on a type of player. Still, a part of it covers portions of the other types of players, which is why the decision is taken to orient the module's design towards the kind of player with greater inclination.

Figure 4. The test result of a student with a tendency of ambitious player type.



Source: Own elaboration**.**

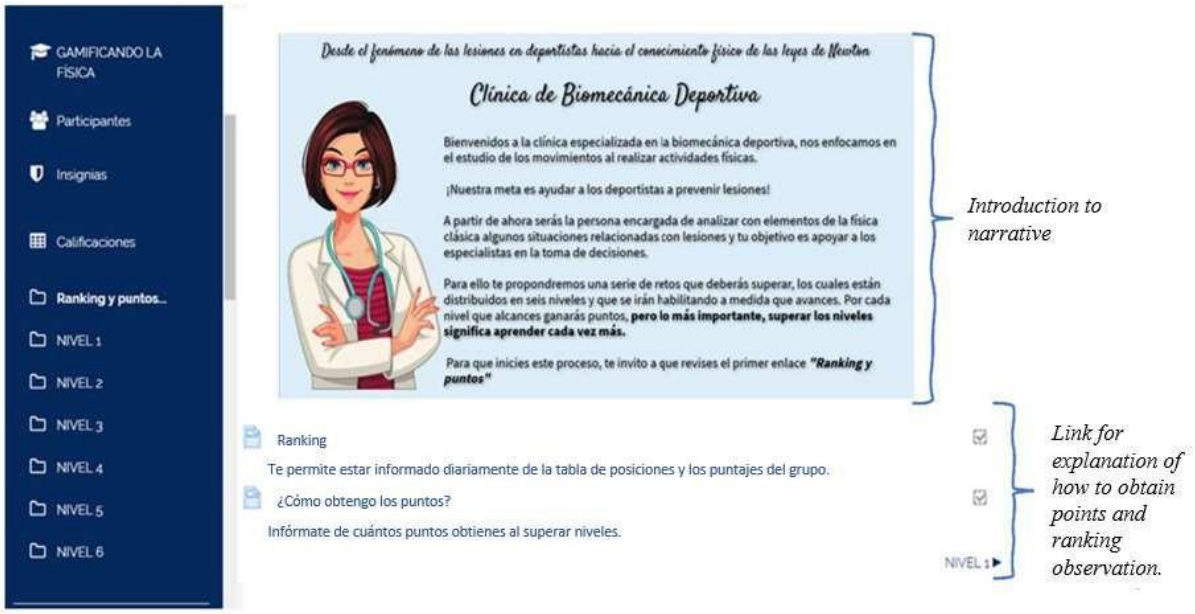
Figure 5. The test result of a student with a tendency to be a Successful player type. Source: Own elaboration.



3.2. Interaction with the gamified unit

According to Werbach and Hunter (2012), a type of gamification is one that seeks to change behavior; in the investigated population, it was aimed to generate a progressive and constant interaction with the platform, and the narrative used was that of a sports biomechanics clinic (fig. 4), since, despite having eight weeks for the delivery of academic responsibilities, students make their deliveries on the deadline, with the gamified proposal the schedule was organized, so that students received incentives for progressively delivering their duties.

Figure 6. Presentation of the study phenomenon in the gamified unit—source: Own elaboration.



With the implementation, it was possible to determine that, of the fourteen students, twelve made their deliveries progressively and before the established dates, which suggests that the gamified unit managed to incentivize them to such an extent that they organized themselves to achieve the rewards and therefore the learning.

3.3. Holistic learning

This category describes the students' learning from a holistic dimension of the PBL; it is clarified that this dimension is developed with an emergent character, given that the phenomenon of injuries in athletes in the gamified unit combines themes and contents of different subjects. Still, they do not merge completely; the research propitiated in the student's conscious search for the connection of the phenomenon with other areas of knowledge, that is why the characterization shown below was based on the learning demonstrated by the students from different subjects, which are still disaggregated in the school curriculum of the institution.

In the first measure, there are the explanations of the phenomenon that students make taking into account their learning in the subjects of Physics, Chemistry, and Biology; it is the case of the following student who highlights the movement and force as the factors that produce an injury, likewise, he emphasizes in his oral and written speech, the daily interaction that he began to observe between science and everyday life, an aspect that he highlighted in the synchronous encounter, emphasizing that before the activity he had not noticed such relationship:

> "For my part, I have mainly learned the union that sciences such as chemistry, and physics, have with actions that we perform day after day and with many of the phenomena that happen to us daily, how the movement of bodies influences many injuries and in turn, such injuries are generated by forces that we exert and that we receive from our environment."

Like the above, the following intervention stands out: first, the fact of looking for contextual examples (soccer) to explain more easily the physical aspects that influence the injury; second, the use of the word deduces to refer to their understanding that the

phenomenon can be sustained using scientific concepts and, more precisely explain the severity of an injury:

> "In cases such as in soccer, when a player is running and suffers a fall, one can deduce the severity of the injury using physics concepts such as velocity, acceleration, and mass, among others."

In the following case, it is also proposed that physics is an essential element in determining the severity of the injury; it shows a direct relationship with the force that can be exerted on the body. In addition, the biological aspect takes relevance by recognizing that bones and muscles can be the most affected in sports injuries:

> "In biology, depending on the affected area, it can be established which bone or muscle was affected when performing the sport and thus solve it more easily. In physics, the severity of the injury can be determined depending on the force or trajectory that the object has taken towards the subject."

In addition to the previous examples, the following student explains the cause of the injury from different perspectives; he noted a more significant appropriation for the topics addressed in the physics course.

> "Being an injury of some part of the body is directly related to biology since this is the science that studies living beings and their system. An example also related to chemistry can be the hematoma, which is the accumulation of blood caused by internal bleeding (...) that usually appears as a bodily response resulting from a blow, a contusion, or a bruise. And in physics, it is directly related to the amount of energy a body has been subjected to since injuries are more likely if it is subjected to great effort."

At this point, it is essential to make available a feature that draws attention in the research; being athletes, students emphasized three components: prevention, cause, and cure; the following case illustrates well what was raised:

> "In physics, we can see how the injury could have occurred (physically) and determine the cause. In biology, we can see the inside of the injury and how to cure it. In chemistry, we can create the drugs for the injury. In mathematics, we can determine the force as in physics and what caused it. In physical education, we can know how to prevent it. In philosophy, we can understand how our surroundings affected the injury. In Social, we can know how to help the injured person, and finally, in computer science, we can generate solutions to the injury."

In the previous narrative, we can find an advance in the connections made with other subjects; it is relevant to highlight that, for him, Philosophy, Social Sciences, and Computer Science revolve around the help that can be given to an injured person.

Finally, there is the case of a student who, in her search, transcends a conventional field; her explanation was an inquiry focused on biological systems and their relationship with the development of mathematical models. While she expresses that mathematics will never have an exact model for the complexity of the human body, in an interdisciplinary way, a union between several sciences can be found to solve problems of the injury phenomenon:

> "The methods that have been studied mathematically have contributed to the solution of real and complex problems; for example, in injuries with ligaments; you can determine the damaged fibers and calculate the loss of mobility; physically speaking, you can calculate the force that was used for this injury to occur and perhaps generate an equation to measure the elongation that the restored fibers may have, you can also get to develop models to help prevent such results, to know, for example, what forces can not be applied and thus not exceed the limit of the human body."

With this category, it was found that the holistic dimension represents a fundamental aspect of developing in students a general vision of what they learn. It was observed in their interest in connecting the phenomenon with different subjects, and being athletes, a concern for preventing injury was found. Concerning the researcher's notes, the need to extend the PBL to the entire school curriculum of the institution to increase the degree of holism in the physics course is raised.

3.4. Contextualized learning

In this category, we find the associations constructed by the students between the main topic of the work with gamification (injuries in athletes) and contextual elements from theirown experiences. In the first place, it is highlighted that injuries are explained through experiences and physical aspects where terms such as "resentment of the body" due to forces are used. An example of this case is the following:

> "I associate the word injury with physical damage to something or someone, Fissure or breakage of something, attacking someone's well-being, change of state, fragility. In my experience, injuries are some resentments that can bother or hurt to do some action, due to a force exceeding the body's limit."

Additionally, concerning other experiences, very much of a personal nature, understanding the phenomenon of the interest in inquiry and searching for information is contextualized. Here we find the case of a student, where the contextualization of her learning is built through the way above, where interest in education relates to life experiences with injuries, with the construction of knowledge of her own body:

> "Well, with academics, I usually take very much to heart; that is, I try to look for more information, have clear knowledge, have a knee problem, and have hyperlaxity in the joints. So I have had therapy since I was a little girl because I also used to do sports. I don't do it anymore, which sometimes generates certain difficulties for me, so I also started to understand a little bit in the therapies, what they said about the subject"

Another aspect of contextuality is observed when the possibility of preventing injuries in sports is noticed. The following cases refer to the necessary knowledge of the different types of footwear for sports practices:

> "Sports footwear is essential to be able to move and exercise properly. Learning about the different types and the differences of the shoe depending on the sport helps us improve our performance and decrease physical injuries or pain."
>
> "I learned that it is essential to choose in a correct way the sports shoes since this can be the one that prevents an injury and also the one that can help us to have more performance in the sports practice."

In this case, students propose meaningful learning about sports footwear, noting that they considered the type of shoe to improve performance and prevent injuries.

Considering what was described above, other students show interest in assuming an attitude of care by understanding how forces can affect and cause damage to their bodies, thus denoting them learning for their sporting life, and the importance of knowing physical concepts and learning how to manage them as fundamental elements to control body capacities and prevent injuries:

> "I have learned how physics and forces can affect our body and that everything has a relationship and if we exceed our physical capabilities or forces applied against other forces such as friction and resistance, we can hurt ourselves and cause injuries."
>
> "Physics both within us and around us affects us in many ways, and we must learn to manage it because if we exceed our physical capabilities against external forces such as resistance and friction, we can cause serious physical harm or injury."

On the other hand, it is found that one student expresses that she can apply what she has learned in everyday life; knowing that she mentioned in the synchronous encounter that, for her, physics was limited to doing theoretical problems, far from her life and she finds that it applies in everything, in her words:

> "Mathematics and physics can be applied to everything, and to see that it is a useful tool for the science of medicine, is impressive. To draw one's hypotheses from such a structurally cowaitwaitttttttttt is fun; it gives food for thought and to be aware that a few centimeters can be harmful or life-saving."

The following student proposes a fundamental aspect to knowing elements of physics to understand movement and, in turn, understand concepts as "simple as walking." This learning is contextual because it allows the student to achieve a level of awareness between theory and everyday life.

> "I learned that friction and the force exerted towards the ground is fundamental in movement; and that it is through this those forces are achieved to perform actions as common as walking, and even standing."

Since this student is passionate about sports and wants to study physical education, the topic addressed in the levels is relevant and contextual; it allowed her to have a different look at the career in which she wants to work:

> “The activity was super prone because one of the things I want to do is to study physical education. After all, I am very interested in sports. When I saw that the activity was about injuries in sports and their relationship with physics, I said wow, I read it; it increased my interest in the study of physics in sports."

Finally, in another case, the learning generated towards the physical elements that "you can see in your day-to-day" is exposed, not only in the theoretical field but applying it to aspects of their environment, such as sports shoes.

> "With this activity, I learned that cushioning, flexibility, weight, traction, and support are concepts that we can see in our day-to-day lives (when I wear a shoe, for example), and I was able to study each of their characteristics and physical concepts, how they work and why they do it. I can apply it not only in my sport but in my daily life."

This contextuality category encouragedstudents to explain through experiences in the phenomenon of injuries; it highlighted how they began to use elements of physics in a conscious way to explain events in their sports life, highlighting the relationship between the use of sports elements, their interactions with the game spaces, and the idea of prevention with a scientific basis.

3.5. Learning related to the Authenticity category

This category shows how relevant to the current world of the student was the phenomenon of injuries; the first notable aspect that was found is related to the utility they give to what they learned; a first example is from the student1 who, from his consultations, manifests the influence it has for his sports process:

> "I never imagined that tennis shoes that can influence me to improve my sports performance and prevent injuries, issues such as cushioning and type of sole are fundamental to improve in what I do, from now on I will pay attention to that detail."

The following student describes physics as applicable, stating that the knowledge of forces helps vent and cure sports injuries.

> "Physics and how we understand or use it can be very useful for us to be able to see how the different physical forces such as stroke, surface, resistance, dimension and more affect our body and generate injuries besides being able to generate solutions and cure them"

The student mentioned below finds useful for his near future what he learned in the learning unit; h; hook into account the concepts of traction and grip and relate it to the friction force of the footwear to choose in his daily life:

> "It is interesting to see that the shoes you wear give a direct impact on your body, there was already information I knew, but terms like traction and grip I did not, this information will prove useful in the future to choose a good pair of tennis shoes that will serve accurately in my practices."

Following the usefulness, the following student critically analyzes the recommendation; she uses the word reliable to support that the research around the subject matter guarantees that the knowledge acquired is truthful.

> "The fact that a doctor endorses one type of footwear does not mean that you cannot use others; he is only concerned with guaranteeing a healthy, safe, and reliable development."

In the authenticity category, the idea of usefulness they find in the learned topic was an essential aspect for; the students; it was relevant that the activities addressed were related to their environment, and they managed to connect what they learned with experience from their natural world.

This category allows identifying the learning that students constructed around the topic of force and the relationships they make with the phenomenon of injuries. As the first aspect is the notion of force as a vector magnitude, students identify vital aspects such as direction and sense, for example:

3.6. Learning about "Strength."

> "There are many forces, not only the one you exert when you carry something heavy, when you walk, move something; an interesting aspect is that depending on how you do the force and where you do it, it will change its intensity. I noticed it in the tensile force in the rope play."

> "I read that force has magnitude, direction, and sense, which could be applied. For example, in my sport, when I play tennis, the inclination influences the power I can generate on the ball."

In the previous case, the student describes, through his experience, how the direction of the force influences the result, a positive aspect because he does not see the physical concepts isolated from what he does daily.

Regarding the learning of force as interaction, it is found that they recognize it as the action that can produce deformation and movement in bodies. Pimples, students two and eight mentions mention:

> "Force is complicated to describe; I could say that it is when you apply force to an object to make it change its shape or move it."
> "For me, the force itself is like the physical ability to move"

In the situation below, the student recognizes that forces cause deformation; his explanation assumes an animistic view, where objects tend to deform:

> "In physics, injuries occur when a body exceeds its limit in terms of something, and because of that, the body tends to deform."

On the other hand, force is directly related to the phenomenon of injuries in athletes; the following student has the notion of force = energy; for him, the body as a material can withstand specific before getting injured. However, his idea of effort = force allows him to understand that the greater the latter, the more damage it causes injuries to occur when a body sees its resistance limit exceeded by the energy it has been subjected to. This can happen while practicing any sport or doing any exercise.

> "…this effort can lead to different types of injuries depending on the impact, for example, from less to more serious: muscle pain (lumbago), swelling, tear, sprain, soft tissue injury, for instance, that of the Achilles tendon, fractures, dislocations or even in extreme cases amputations."

Additionally, the student provides widespread concrete examples of injuries in sports practices, which makes the relationship between strength and sport contextual. Other students find essential elements related to power in sports footwear, as in this case:

> "I learned the relationship between the different materials and the protection they can provide to the parts of our body most vulnerable to injury; likewise, as a sufficiently soft material, it provides the necessary cushioning to counteract any force that can produce any injury or damage to the body, since this object serves to receive these impacts in a way that slows them down in a slow and controlled manner, making them lose strength gradually."

Thus, in the force category, it stands out that students recognized the concept of force as an interaction between bodies, the simultaneity of action, and from the purely qualitative concept, as the action that is experienced through the sense of touch when pushing or pulling an object.

3.7. Learning related to Newton's Laws

Text here This category allows us to recognize the students' learning concerning Newton's Laws and their relationships with the phenomenon of injury. The first aspect that was found in the explanation of the students is the definition of Newton's first law alluding to examples of their everyday life; an essential aspect that they consider is inertia as a property of bodies; an example of what was raised is:

> "The first law, well it would be, if one is in the subway, well here in Medellin it is a subway, when the subway stops one kind of goes forward, for example, if the subway starts one goes backward because one tries to remain in its state of rest, ah, but that is the other thing the inertia. The first law could explain this: if an object is in motion, it tends to stay in uniform motion; if it is at rest, it tends to stay at rest until an external force is applied to it."

Note that the student considered the characterization of inertia as property and theoretically formulated the law of inertia in his own words.

In the following cases, students give an example of inertia, making simple formulations with aspects of their environment.

> "Well, I see it as if one goes in a car and if it brakes, the body suddenly goes forward, that is, it goes forward to try in itself like not to fall, but if it is in a state of rest, then the body tries to stay in the state in which it is, that is to say, to stay in the position, that is an example of inertia."
> "If I have this object on my hand, let's say I don't shake, the object will stay at rest indefinitely until someone else puts a force on it."

Regarding the relationship with the phenomenon of injury, the research did not find a direct relationship with this topic; upon inquiring with the students, they stated that for them, the law of inertia tends to have entirely theoretical aspects because a uniform motion is required for the theory to be fulfilled, they expose the interest of seeing inertia as a property of the bodies in some phenomena, which were mentioned in previous paragraphs.

Concerning Newton's second law, an interest in the subject was found, which was manifested in the synchronous meetings; it was recognized in their effusiveness when giving examples and explanations related to their daily life, demonstrating a more significant appropriation of the topics. Among the learnings, first, it is highlighted that they recognize the relationship of proportionality between force and acceleration; the following student identifies as the main reason for the increase in velocity the fact that the net force is unbalanced:

> "The movement is accelerated because the velocity is changing concerning time because the forces are not in equilibrium, the greater force produces the body to accelerate concerning time thus increasing the velocity."

Another example where the student exposes that the imbalance of forces is an important cause in the acceleration of bodies is:

> "The movement would be accelerated because over time the force increases do not stay the same or uniform, since this is not constant, causing an imbalance of forces, making the body accelerate."

On the other hand, students relate the second law of dynamics with the phenomenon studied in the unit; the following case shows the relationship made by the student between force and acceleration; the interesting point is that he infers that there are contact forces that can stop the movement of the body and tries to explain a possible injury through the example he provides:

> "I learned that, when performing an inequality of forces on an object, this leads to a sudden acceleration; the only thing that could stop the movement would be that an opposing force is presented that stops it gradually or suddenly; all this can be taken as an example by imagining a person running, who stumbles by generating too much friction with the ground by not lifting his feet properly."

Another example of the relationships between the studied phenomenon and Newton's second law is shown below; the analysis of friction as an element that influences the movement of a body is highlighted in her written discourse.

> "With this activity, I have learned that the accelerated movement is presented depending on the speed that an athlete takes as a function of time; in the same way, there are different variables that must be considered for a body to present a certain acceleration such as force and especially friction. I understood that depending on the athlete's mass and the force applied or applied to him, injury; injuries generated."

Continuing with the learning regarding the second law of motion, the following students relate momentum to acceleration; for them, traction generates enough friction between the sole and the surface to cause an effective start in the athlete; through observations and analysis of their sports, they manage to make an association:

> "The friction between the shoe and the surface is significant for the body's momentum and braking. This sole will condition the traction and grip, making it easy to run, take impulse, and brake whenever necessary."
> "The friction between the shoe and the surface generates loads to propel the body in the desired direction and brake or stabilize the foot on the ground. The characteristics of the sole will condition the traction and grip of the sports shoe."
> "During the execution of the various sports movements, friction acts between the footwear and the surface, generating loads necessary both for the impulsion of the body in the desired direction and to brake or stabilize the foot"

It is necessary to clarify that in the synchronous encounter, there is a dialogue with the students about the concept of impulse, and the group of students contextualizes the relationship of this concept with that of force. Finally, the students' learning concerning Newton's third law is interpreted in this category. First, it is found that students account for the causality of the phenomenon; for example, one has:

> "At the time of running, the more force we exert to the ground this will return us the same amount, but in the opposite direction influencing in giving us impulse and depending on the physical state greater or lesser exhaustion. In addition, depending on the material of the floor, the foot does not sink and maintains the force of the impulse without losing speed."

The student explains through examples the action and reaction generated in the body in a contextual case for him; his explanation denotes an understanding of the physical process. Another point to highlight regarding the causality of the phenomenon is the following, where the student recognizes a relationship between the "push" that a person makes against the ground when walking and the reaction that moves.

> "For example, to the question, if I make force towards where I walk, theoretically no since you make the force in the opposite direction for where you want to go, for example: when you want to go forward you are pushing the ground backward so that the reaction of this movement takes you forward."

A second aspect to consider in this law is the interaction between bodies; from the idea of action and reaction, student four focuses his speech on the interaction between the foot, ankles, and knees – the nsolesole of the shoe with shock absorber, the force that the shoe does to the foot is the same in magnitude that the foot does to the shoe. That interaction of the pair of points could be more significant in intensity if the shock absorber were not functioning and, in such a case, would generate damage.

> "The insole has high cushioning to avoid any injury to the joints, reducing the force when falling while jogging or walking, since it is very likely that, with less cushioning, the same joints would not be able to receive all the force and generate some problem in ankles and knees. Similarly, by presenting less hardness in the sole, greater stability is generated between shoe and foot, avoiding any slip and helping to absorb impacts with the ground."

Another case concerning the above-mentioned is that of student ten, who recognizes the interaction and the relationship: runner's footprint - ground reaction, understands the importance of friction in displacement.

> "The ground reaction when we run, walk or just stand is critical because friction affects our forward movement and our movements, and our techniques affect our speed, forward movement, muscles, and joints."

Finally, students, through their narratives, recognize and qualitatively explain the third principle; they also relate it to everyday aspects; some examples are shown below:

> "When we walk, we "push" the ground backward so that, according to the principle of action and reaction, the ground pushes us with the same magnitude and opposite direction. This is what propels us forward and allows us to walk. Something to keep in mind here is the frictional force."
>
> "If an object A exerts a force on an object B, then object B must exert a force of equal magnitude in the opposite direction on object A., E.g., A person walking exerts a force backward on the floor, the floor exerts a reaction force on the person that causes him to move forward."
>
> The ground, being a static object that always remains in inertia, produces a force equal to the point we apply to it, generating a relationship of action and reaction, in which, depending on how much energy we use on it, we will receive that staff projected on us".

For this category, it was found that students associate inertia as a property of bodies, stating that they can observe this property in their environment; however, it is difficult for them to find experiences that allow them to replicate it in settings where they follow the uniform motion and in a straight line in their daily lives, as for the second law it was denoted in their interest in knowing the incidence of this theory in their sports, In addition, in their explanations, they make reference to impulsive force, proportionality between power and

acceleration, as well as the third law, it was easier for them to understand that there must be two forces of equal magnitude, but in the opposite direction for this law to be effective.

3.8. Learning and gamification

This category considers the students' learning when they were in contact with the gamified unit and what the interaction with elements different from those they were used to in previous physics courses aroused in them. In the first place, the motivation generated by the initial approach with the context is highlighted; for this case, a student mention:

> "Well, when I saw it, I thought it was a bit strange because there were no activities, then I read the instruction and saw that it was by levels; I said Well, it is striking and interesting, let's say that it encourages that one wants to overcome it, as soon as possible. It's a kind of healthy competitiveness."

For the previous case, García, Bonilla, and Diego (2018) ratify that "awakening the interest of students through the use of methodologies that allow them to participate actively and feel protagonists of their learning will promote motivation" (p. 89), a situation that was observed in the population under investigation, tenth grade, and that for the case of a student, is connected with his statement about wanting to meet the challenges.

Another case where the idea of motivation is manifested is the following:

> "Well, yes, it seemed to me that the method is like an excellent learning method because one is kind of more motivated since it is in the form of a game, then it is like more fun and, well, since it is fun one learns more."

Note that the student establishes a connection between context, motivation, and fun to talk about her learning. In line with the above, the following student implies that this didactic way of working not only amuses and motivates her it also allows her to apply what she has learnedin authentic contexts.

> "These activities were quite fun because knowing where physics is specifically applied in real and everyday life gives the motivation to understand the subject with this didactic form."

Now, motivation, in some cases, arises as an opportunity that controverts the traditional, where the usual of the classes is questioned when compared to gamification. This is the following case:

> "I find it very interesting to be able to learn differently, because normally we always learn, well, everything theoretical and they are exercises, like the same as always, so to speak, then this activity as if it were a game with levels, and all this helped me to want to learn more and to want, well, to do it faster and see how the concepts in a better way."

Note that the student relates being motivated to learn more through gamification, highlighting the character of both organizations as a game and organization as progress, a situation that associates it with learning concepts more

favorably than with the usual ways in which she knew.

In the second place, it is found that the gamification unit at the first contact with the student makes possible some new ways of feeling in the possibility of fulfilling the associated activities. We have here this case:

> "I was shocked to see the first activity that I did not have to start with complex exercises or topics that I know I would procrastinate; I realized that only one word can be attributed differently in various sciences because it is clear that there are many concepts that employ this situation, it is quite interesting."

As can be seen, the student expresses surprise, something uncommon in the educational institution, where students are accustomed to a learning cycle. In her oral narrative, when she was in the synchronous session, in an emotional way, she shared her experience when she saw that she could not postpone the work to be developed due to the format in which it was presented to her (gamified), but mainly, because she expected pencil and paper exercises as usually proposed in the course. This shows that the gamified unit positively altered her behavior toward the course activities.

Another aspect that stands out of the student's relationship with the gamified system is the immersion that one has with the proposed narrative, being in contact with students who incline toward sports, the history of the sports clinic, and the "advice" that the students had to give, allowed them to get involved with the activity, for the case, a student raises what is shown below:

> "For this reason, I recommend the athlete use the product since it depends on this that there is a good relationship concerning the sport being practiced and that possible injuries can be avoided."

In another case, one student enters the universe of gamification, i.e., his narrative is contextual to the point of the sports biomechanics clinic, and the explanatory coherence is like that of an expert when describing the characteristics of the shoes.

> "As you can see from the sole of the shoe and its shapes, this shoe has good friction or grip that makes the body's momentum towards one direction and stabilization or braking safe and fast."

In this category, it was found that gamification contributed significantly to students' motivation when interacting with the material; the surprise was an essential aspect in the development of the activities proposed, a part that some students highlighted by stating that this subject can be understood differently.

4. Conclusions

Interdisciplinary learning as a holistic and contextual construction: students showed interest in generating connections between the base theme of the unit and what was learned in other subjects; for them, the most critical link was presented with biological, chemical, and of course, physical sciences. The descriptions made by the students highlighted the need for prevention and how the sciences allow them to learn truthful elements for decision making, not only in scientific subjects. This learning included using previous knowledge from their daily activities and sports to contrast them with scientific explanations from a physical environment where the topic of sports shoes caught their attention.

Understanding the technology and the physics implicit in them surprised part of the sample. Also, the relationship between their experiences with the theoretical aspects allowed them to recognize that physics is in all aspects of their daily life.

Learning helpful knowledge as a reflective process of knowledge: The students demonstrated the search for awareness to understand the usefulness of the learning obtained in their real life and how the sciences (not only physics) are immersed in their daily activities. Thus, for example, regarding the idea of force, from a theoretical aspect, the students recognized the concept as an interaction between bodies, understood that action is simultaneous and from the purely qualitative concept, explained the force as the action that is experienced through the sense of touch when pushing or pulling some object. They recognized the vector nature of forces and related it to examples from their daily lives. In the development of the activities, they understood the concept of constant motion and the conditions necessary for it to exist.

Thus, the research was able to determine that by considering the phenomenon of injuries, the gap between theoretical learning and everyday learning was substantially reduced since the students were able to expand their knowledge on the topic studied and apply it to their daily lives, which gave a greater sense of usefulness to the inside.

Motivation as a part of the re-cognizing the phenomena: In the gamification category, the findings showed the basis generated in the students when they found activity in the form of a "game" (as they called it), the automatic unlocking of levels in the Moodle platform allowed them to challenge themselves to reach the goal more quickly, the narrative used (sports clinic) allowed them to be part of the construction of their learning. An element that helped in the success of this implementation was the novelty that the proposed activity represented for the group of students, where they could have some control over their learning, the search for information, and the benefits they could have by achieving the proposed goals.

Gamification is not synonymous with video games; the consultations describe the characteristics of gamified systems. These systems can be implemented with the resources available to the teacher (they can be physical or interactive). The canvas model allows the mechanics, dynamics, and components to organize quickly and adequately.

Gamification, in a general sense, is not a new aspect in the teaching practice; it has always been immersed in the development of classroom activities; however, since gamification began to be used, the necessary formalism has been given to replicate and extend the use of such systems properly, it is essential to understand that not everything can be gamified and that a previous analysis of the population must be done to implement the system appropriately.

From a teacher's perspective, the research allowed a transformation in educational practices, constantly seeking innovation in the processes carried out daily. As a teacher directive, it allowed the change of the institutional school curriculum to begin, encouraging gamification to become part of the school's daily life. From the learning in physics didactics, horizons were broadened to such an extent that the conception that equations and solving exercises in a textbook should be a central part of the physics learning process was questioned.

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