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Journal Practical Didactics

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Presentation of Content

In the first article we present, *Verbal reasoning, a tool to develop mathematical thinking at the upper middle level,* by SÁNCHEZ-LÓPEZ, Guillermina, SALGADO-SUÁREZ Gladys Denisse, GONZÁLEZ-LOZADA Ma. de Lourdes and BÁEZ-AMAZTAL, María Isabel, with adscription in the Benemérita Universidad Autónoma de Puebla, as the following article we present, *Gamification in the field of initial music education. An innovative teachinglearning strategy,* by MARTÍNEZ HERNÁNDEZ, Gerardo & BORISLOVA, Nadezhda, with adscription in the Benemérita Universidad Autónoma de Puebla, as the following article we present, *Design and validation of an instrument to evaluate the implementation of STEAM with a focus on inquiry for learning the Solar System on elementary school,* by DOMINGUEZ-GUTU, Jesús, TREJO-TREJO, Gilberto Abelino, GORDILLO-ESPINOZA, Emmanuel and CONSTANTINO-GONZÁLEZ, Fernando Exiquio, with adscription in the Universidad Tecnológica de la Selva, as the last article we present, *Implementation of a greenhouse as a sustainability teaching strategy at university level,* by RANGEL-RUIZ, Karelia Liliana & GRANADOS-OLVERA, Jorge Alberto, with adscription in the Universidad Politécnica de Cuautitlán Izcalli, Universidad Tecnológica Fidel Velázquez.

Content

Article **Journal Practical Didactics**
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Verbal reasoning, a tool to develop mathematical thinking at the upper middle level

El razonamiento verbal, una herramienta para desarrollar el pensamiento matemático, en el nivel medio superior

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Abstract

Objectives To establish a proposal to improve the school performance of engineering students, as a consequence of the development of reading comprehension. Methodology: The proposed research methodology was qualitative by the controlled trial method. It was applied to five groups in the first semester and one more to contrast the results, to identify the existing problems about academic performance considering as variables: poor grades, adaptation, study habits, reading comprehension, mathematical reasoning, emotional problems. With the results obtained in the diagnosis, some improvement strategies were established and throughout the semester the detected students were accompanied, these strategies were modified according to the pre-results that were given. At the middle and end of the semester, evaluations were applied to identify the effectiveness of the measures used. Contribution: This educational intervention proposal arises with the purpose of developing mathematical reasoning in the students of BUAP high schools.

Reading comprehension, Reasoning Mathematician

Resumen

Objetivos Establecer una propuesta que permita mejorar el rendimiento escolar de los estudiantes de ingeniería como consecuencia del desarrollo de la comprensión lectora. Metodología: La metodología de investigación propuesta fue cualitativa por el método de ensayo controlado. aplicándose a cinco grupos de primer semestre y uno más para contrastar los resultados, para identificar los problemas existentes sobre rendimiento académico considerando como variables: malas calificaciones, adaptación, hábitos de estudio, comprensión lectora, razonamiento matemático, problemas emocionales. Con los resultados obtenidos en el diagnóstico se establecieron algunas estrategias de mejora y a lo largo del semestre se fue brindando acompañamiento a los estudiantes detectados, estas estrategias fueron modificándose conforme a los pre-resultados que se iban dando. A mitad y a final de semestre, se aplicaron evaluaciones para identificar la eficacia de las medidas utilizadas. Contribución: La presente propuesta de intervención educativa surge con la finalidad de desarrollar el razonamiento matemático en los estudiantes de las preparatorias BUAP.

Comprensión de lectura, Razonamiento Matemático

Citation: SÁNCHEZ-LÓPEZ, Guillermina, SALGADO-SUÁREZ Gladys Denisse, GONZÁLEZ-LOZADA Ma. de Lourdes and BÁEZ-AMAZTAL, María Isabel. Verbal reasoning, a tool to develop mathematical thinking at the upper middle level. Journal Practical Didactics. 2023, 7-17: 1-9

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Introduction

In the INEGI website, it is shown that, at national level, in the upper secondary level there is the highest rate of school dropout, unlike the levels that precede it, in the case of Puebla the situation that is presented is similar. This situation is multifactorial, from economic, family, personal problems, deaths of the economic provider of the family, lack of interest or motivation, bad behaviour, to academic ones with low performance and comprehension in some subjects.

Among these academic factors is the low performance in mathematics at the national level, a problem that has been reflected in the Planea and/or PISA standardised tests applied to students at this level, both for reading comprehension and mathematical performance.

This paper seeks to determine how the problem of school dropout can be solved.

Failure in mathematics is not only a question of lack of knowledge or management of the algorithms that solve the different operations, in most cases the lack of understanding of the statement of the problems presented to the students causes the impossibility to model and therefore raise and interpret the solution expected by the teacher.

It is vitally important to understand what is read in mathematics, as Cantoral, (2018) mentions, given that it is necessary to first understand what the problem says in order to solve it.

In order to understand a text, the reader internally carries out several processes that range from decoding signs to constructing the meaning of the text.

Will this be equally difficult for men and women, and will both have the same problem in terms of reading comprehension?

In this paper, progress will be presented with regard to the investigation of this problem.

Theoretical framework

The implementation of the competency-based model at a higher level is accompanied by the link between the study programme and the needs of the labour spheres, with the aim that upon graduation, students are capable of entering the productive field. In the case of mechatronics engineering at the Technological University of Puebla, the requirements are high, due to the fact that it is necessary to achieve a great development of reasoning skills, analysis, modelling, argumentation, solution planning, etc., which the students must put into practice from the very beginning. . This development is gradual and all the subjects that make up the school curriculum contribute to this training, taking into account that knowledge should not only be transmitted.

As mentioned by López, (2019), the competency-based model arises with the aim of responding to the requirements of different political, social and economic spheres, trying to form a relationship between these, requiring the active participation of teachers and students, thus forming a triangulation between social needs - the individual who learns integrally and the educational structure.

This triangulation motivates a complete change both in the way of teaching and in what should be considered for evaluation.

As for the way of teaching, it takes into account the way in which the student learns, his or her abilities: emotional, psychological, creative, socio-emotional, etcetera.

One of the main problems that the competency-based model has presented since its beginnings is the debate caused by the diversity of conceptualisations of the term competency supported by different approaches and tried to explain at different educational levels.

Among the coincidences of the aforementioned approaches is the etymological origin of the word competence, which is "competere", i.e. responsible for something (López, 2019). This generates a starting point for the modification of curricula in the various curricula.

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An important pillar of the above is the proposal that Moreno (2012) makes with regard to competence, indicating that this includes the ability to meet complex demands, for which psychosocial resources are put into practice. (López, 2019).

The concept of "competent" implies the mobilisation of knowledge by the individual to apply it in the practical and efficient resolution of problems, in any area where he/she works, be it personal, social, work or professional.

As mentioned by Tejada and Navío, (2005); Guzmán, (2012), in order to be competent, the individual must put into practice all his or her abilities, so that the achievements obtained must be observed in order to assess them.

Mathematical reasoning in the education of upper secondary school students.

The education of high school students is an integral process that is accompanied by the development of skills and abilities, which, like puzzle pieces, are interwoven with previous knowledge and scaffolded with new knowledge.

The relationship between learning and understanding are interrelated terms, as both imply a mutual, complementary process related to internal and external factors of each of the students, including the teacher. Its conceptualisation, as mentioned by Solano, (2015), has been modified according to different educational trends, from internal to environmental factors, and currently great importance has been given to considering that learning is characterised by being socio-constructive, i.e. a process, as stated by Gajardo, (2012) that is social, cultural and interpersonal.

The learner receives, selects and stores information; encodes, analyses and interprets it in order to construct knowledge.

Currently, the study of intelligence and mental aptitudes is approached both from philosophy, psychology and neuroscience and from linguistics, mathematical logic and advances in computing and electronics (Solano, 2015).

From psychology, he basically explains that mental aptitudes (verbal comprehension, abstract reasoning and memory) can be studied from factorial theories with different models, theories of information processing, cognitive theories and emotional intelligence.

Of the factorial theories, Thurstone's hierarchical theory (American School) states that the subject's reasoning ability depends on creativity and intelligence, the latter being made up of seven factors or mental aptitudes: a) Verbal comprehension; b) Verbal fluency; c) Numerical factor; d) Spatial aptitude; e) Mechanical memory; f) Perceptual speed; and g) Inductive reasoning.

On the other hand, mathematical reasoning is the ability that allows individuals to make use of numbers, symbols to model the solution of everyday problems, not only academic, this form of reasoning is useful to generate computer algorithms and subsequently develop and apply software programs, or for the design of functional structures in engineering, or in decision making in investments or in different businesses.

Mathematical reasoning is logical, structured, analytical, precise and creative, and it is obvious that all these characteristics are developed by learners throughout their academic preparation.

Developing mathematical reasoning brings benefits not only in solving problems, but also in fostering logical thinking and thus the ability to think in a logical and organised manner, improving decision-making, enhancing memory development and increasing creativity.

Pólya, (1965), stresses the importance of mathematical reasoning in solving problem situations, emphasising the importance of identifying patterns, using problem-solving strategies and developing critical thinking skills.

Lockhart, (2008), argues that traditional mathematics education focuses too much on procedures and calculations, and not enough on mathematical reasoning, so it is necessary to make a change that allows and promotes creativity so that students can discover and experiment for themselves.

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Skemp, (1993), highlights the importance of mathematical reasoning in the conceptualisation of problems, arguing that this not only involves doing operations, but understanding and applying concepts by making connections between different mathematical ideas.

Boaler, (2020), argues that mathematical reasoning is fundamental to the development of sound mathematical skills and problem solving in everyday life, emphasising the importance of cultivating an open mind towards mathematics.

Reading comprehension and its influence on the upper secondary student

Durán, (2018), describes that in any learning process and therefore the creation of knowledge, reading is of great importance and in addition to this, the comprehension of what is read is vital to achieve an understanding of what is expressed in the texts, the lack of this skill is one of the causes of low academic performance of students. Authors such as Márquez, L., et. al. (2017): Uribe, (2014); raise the difficulties faced by teachers of institutions when they want to apply reading comprehension by students and realise that they have not developed it as expected according to their school level, reading also involves identifying the writer's objective, what he intends to express, how he does it and what impact it has, so that a reader is considered effective, if and only if he reads, understands and perceives.

Reading comprehension is, therefore, the process by which, as mentioned by Durán, (2018), meaning is constructed through mutual exchange with what is read, making use of the imagination, previous knowledge, experiences, so that the inference of what is read is made, with the aim of developing communicative competence, thereby building new knowledge that achieves its active intervention with the society in which it develops. According to the International Programme for Student Assessment PISA, (2009), the ability to use reading to develop knowledge according to the interests of the reader is defined as reading comprehension, which can be hindered depending on certain characteristics of the text, such as the level of language used by the writer or the organisation of the information contained therein.

The problem of the lack of development of the reading habit in the general population has worsened in recent times, it is interesting to mention that several studies since 1998, tell us about this as a major academic problem that impacted all subjects at all levels of academic degrees, currently social networks cause readers of no more than 140 characters which is the maximum that can be written on Twitter for example, This is without considering that a large number of those who enter these social networks only scroll up or down the screen without being interested in the publications they see, mobile phones become the ideal pretext to avoid the socialisation of individuals, creating social isolation in the individual who prefers to see the screen of his or her mobile phone.

Neurolinguistically, it is known that for the brain to develop correctly, the individual must read, so that he or she learns and relearns.

The lack of reading habits in students causes delays in the implementation of some teaching-learning strategies such as the "inverted classroom", through which students arrive at the class session with the reading done on the subject to be addressed, which in theory allows a better understanding of what the teacher will apply in the classroom session, but if the student does not read it or even worse if he does not understand it, it is not possible to anchor the previous knowledge with the new, causing with this the construction of knowledge is not achieved.

Interpreting a text is an integral process where both the reader, the text itself and the context that accompanies them are present (Montes, 2014). This reading process is obtained thanks to the decoding, interpretation and understanding carried out by the reader by applying it practically (Díaz, 2002).

On the other hand, in order to understand a reading, it is necessary to analyse and synthesise it in order to link the knowledge that is constructed from it, using the meaning to arrive at deductions.

According to Biggs, (2005), this is achieved depending on the planning that teachers carry out, considering the characteristics of the students, the way in which they learn and the means they have at their disposal to achieve it.

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It is very important to remember that reading goes beyond just seeing signs and identifying them phonetically, an interpretation must be given to those words and therefore to those statements, and here memory plays a great role, since remembering events and previous knowledge is what allows anchoring what is new by giving an interpretation that is meaningful to what is read, these processes are perceptual and cognitive and make use of sequential encodings (Montes, 2014). (Montes, 2014).
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Decoding is an elementary part of understanding a text. Understanding a text involves a high-level process of constructing meaning through linguistic skills (decoding, parsing), memory, attention, reasoning and prior knowledge, etc.

The linguistic skills proposed by Cassany, (1998), depending on the code, are oral or written, and depending on the role they play in the communication process, they are productive or expressive and receptive or comprehension, as shown in Table 2..

Paper / Code	Receptive	Productive
Oral	Listening	Speak
Escrito	Read	Write

Table 1 Classification of language skills according to Cassany, (1998)
Own Creation

Academically from the basic levels in Mexico in recent years the development of the oral code in students has been neglected, considering that only at home is where they are taught to speak and that in educational institutions should only be taught to write, this brings severe consequences in pre-university students who are no longer accustomed to listen or listen while reading, this is not only a consequence of the teachings at the basic levels of their education but is also due to the misuse of social networks and of course the time of distancing given the global health crisis.

In order to achieve the correct development of communicative competence, listening skills are of vital importance, if students pay attention and have concrete expectations of what they are going to hear the comprehension process can take place (Urive, 2006).

During the oral code, Cassany, (1998), mentions that the following processes are developed. Recognising, Selecting, Interpreting, Anticipating, Inferring, Retaining; which are carried out in lesser or greater depth with age, school level and the practice itself.

So, as Urive, (2006) mentions, the Oral code must be educated and trained in students from the most basic educational levels.

In the process of speaking/listening, which in the classroom is practised in class presentations, it is possible to evaluate certain abilities, skills, attitudes and aptitudes, such as:

That the student is able to:

- Plan what he/she is going to say as part of his/her argumentation, resulting in an eloquent speech.
- Analyse the elements and characteristics of the event he/she is describing.
- Produce syntactically ordered and coherent sentences.
- Semantically listen to an intoned speech with the correct pauses according to punctuation, exclamation or question marks. o Pronounce correctly and appropriately according to the punctuation, exclamation or question mark.
- Pronounce correctly and appropriately with a good tone of voice and rhythm.

In the case of pre-university students, achieving an eloquent and argumentative, logical and coherent discourse is a skill that is of vital importance when entering the next academic stage, regardless of the area in which they work.

On the other hand, in the Reading/Writing process, the abilities, skills, attitudes and aptitudes that the student develops are:

- Establishes the relationship between the letter and its sound.
- Pronounces appropriately
- Identifies what words mean
- Reads at a good speed

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- Establishes the correct order of the ideas that the text puts forward.
- Understands the intention of the text
- Reads with intonation.
- Traces letters correctly.
- Uses spelling rules.
- Constructs a text, revises it, identifies errors, redoes it.

As mentioned by Urive (2006), in order to develop reading and writing skills, listening and speaking skills must be developed, and vice versa.

As can be seen, reading comprehension is necessary for the student to be able to "understand", "comprehend" and "establish" the solution to various problem situations that are presented to him/her.

As mentioned by Diaz, (2006), in competence-based study programmes, different teaching and learning strategies are implemented, the main intention of which is the comprehensive training of students so that not only is knowledge transmitted, but there is also a real application of the knowledge that students acquire, thereby promoting meaningful learning in each subject.

The comprehensive education of students is not only a matter of acquiring knowledge, it is also necessary, as established by the OECD (2019), to develop civic skills in students so that they have a direct participation in public affairs, so that the implementation of problems with contextualised situations allows this goal to be achieved and promotes the development of mathematical competence.

The following research questions arise from the above:

Is reading comprehension the basis for the development of mathematical reasoning?

Does increasing reading comprehension activities improve students' comprehension in mathematics subjects?

Objectives

- To determine the level of reading comprehension in upper secondary school students.
- To determine whether the level of mathematical reasoning improves with increased reading comprehension in upper secondary school students.

Methodology

There are different types of research which are defined on the basis of certain characteristics such as: Research purpose, methodology, level of information analysis, sources of information and the area of study (Hernández, 2014).

Based on the above classification the type of research for the work to be implemented in the Regional High School "Simón Bolívar" is according to the order of the previous paragraph: an applied, exploratory, qualitative, field, social-scientific research.

Applied because the knowledge will be used to solve the problems that arise in most higher education institutions; exploratory because it is intended to observe the results of the implementation of some activities that motivate students in collaborative work and at the same time promote meaningful learning in them, so that they can solve contextualised problems; qualitative because the aim is to assess the use of strategies that develop reading comprehension and thus mathematical reasoning in both virtual and face-to-face teaching; field-based because work will be carried out with students in classrooms and it is hoped that it will be enriched based on observations made both face-to-face and virtually; social-scientific because the aim is to understand how teachers can implement strategies in the school modalities that have been established as a result of the health contingency.

The "Simón Bolívar" Regional High School has a total of 1750 students in morning and afternoon shifts, with an average of 38 students per group.

The pilot test of this proposal will be carried out in 5 groups of the project analysis subject, having as a control group to contrast the results by triangulation, one more group in which the strategies will not be applied.

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Taking into account that the total population of students in the third year of high school is 474 and the intervention proposal will be applied to 215, this gives us a reliability of 95% for our study, according to the formula:

$$\text{Tamaño de la muestra} = \frac{\frac{z^2 \times p\,(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p\,(1-p)}{e^2 N}\right)} \quad (1)$$

Formula 1 allows us to determine the optimal sample size to perform a statistical analysis, where N= sample size, e= Margin of error, z= score that depends on the desired reliability value, this is reported in tables, as shown in table 1, for our case we have a value of 1.96 to reach a confidence level of 95%.

Nivel de confianza deseado	Puntuación z
80 %	1.28
85 %	1.44
90 %	1.65
95 %	1.96
99 %	2.58

Table 2 Z-values according to the reliability of the study

Hernández, (2014), mentions that studies can be carried out using two types of sampling, probability and non-probability.

Probabilistic sampling is where the sample is chosen randomly and is in turn classified as systematic, stratified and by clusters.

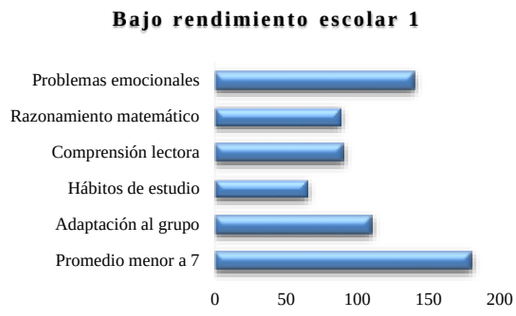
On the other hand, in non-probability sampling, it is the researcher who chooses the sample at his or her discretion and it is classified as purposive, convenience, consecutive, quota and snowball.

In the case of the work implemented in the "Simón Bolívar" Regional High School, we worked by means of non-probabilistic convenience sampling, also known as purposive selection, given that the groups were considered according to the timetable of the teacher who carries it out.

In the present study, it was proposed to evaluate the results obtained in three stages of progress. The first one before starting in order to contrast with the students' response once the teaching-learning activities were implemented and the last phase at the end of the semester to validate if important results were achieved.

Results

The diagnostic evaluation provided, as shown in graph 1, relevant information regarding the academic situation of the students, obtaining that the main causes of low school performance are emotional problems, low mathematical reasoning, low reading comprehension, difficulties in adapting to their peer group and grades below 7



Graph 1 Diagnostic evaluation

With the information from the diagnosis, it was established as a didactic strategy that 15 minutes of the class session, twice a week, a reading on a topic related to the subject would be presented, including readings from the magazine muy interesante, the book el diablo de los números and other articles that allowed the students to see the importance of mathematics in everyday life, In the language subject, which was the academy with which this work was carried out together, the same time was also used for the readings, in their case of topics related to the subject, and after the reading, 3 to 5 questions were asked to determine the comprehension that the students achieved.

Graph 2 shows how each month the level of reading comprehension increased in the group as a whole. In the first week only 20% of the students were able to understand the reading, by the fourth month 95% of the students in the sample were able to understand, explain and discuss what they had read.

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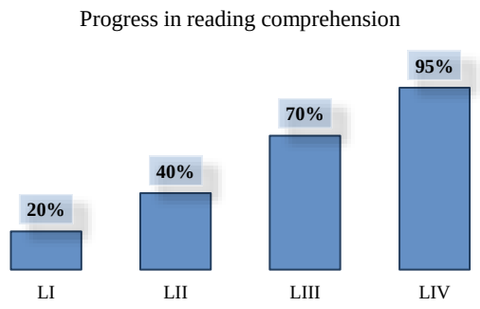
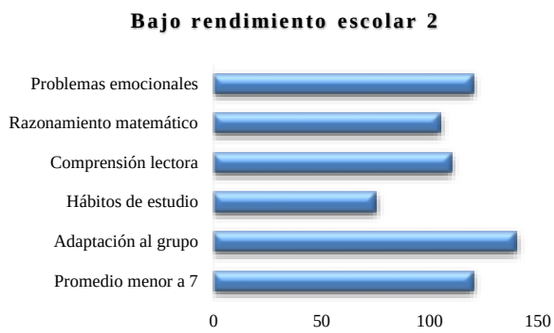


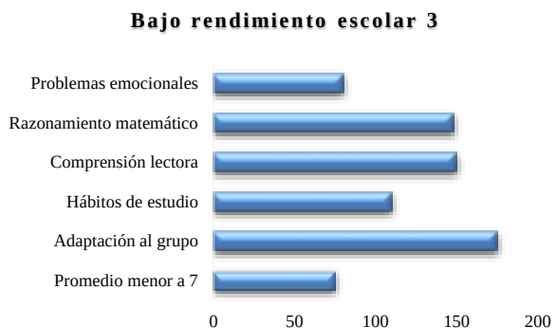
Graph 2 Progress in reading comprehension throughout the semester

Together with this, progress in the other variables was quantified: emotional problems, low mathematical reasoning, low level of reading comprehension, difficulties in adapting to their peer group, and it was very interesting to observe that as reading comprehension improved, the development of mathematical reasoning also improved, as we can see in tables 2 and 3.

These strategies also promoted the adaptation of the students in their group, making progress in the emotional problems that some of them presented, mainly low self-esteem and insecurity in terms of their knowledge or expressing ideas.



Graph 3 School performance second assessment



Graph 4 Final evaluation performance

Conclusions

As Diaz, (2006) mentions, in the study programmes based on competences, different teaching and learning strategies are implemented, which have as their main intention the integral formation of the students so that not only is there a transmission of knowledge but also a real application of the knowledge that the students acquire, thus promoting meaningful learning in each subject. Elías, (2021), mentions that in public or private educational institutions, quality education should be promoted, for which the implementation of strategies that reflect the concern to address the conflictive situations for students, which impact both on their low school performance and in cases of school dropout, therefore these strategies should be comprehensive to take into account socio-emotional, cultural and physical needs of the student community in general.

As a long-term proposal, the authors consider that at the institutional level, all academies should be invited to participate in the practice of reading comprehension, using a few minutes of their classes per week. This will also allow students to realise that this activity is not only for language subjects, but rather that they understand that reading comprehension is the basis for understanding and reasoning in general, for their daily lives.

It is important to emphasise that mathematical competence does not only refer to solving mathematical exercises, but to the development of critical thinking through which individuals are able to identify real problems, model them, propose possible solutions, interpret results and propose strategies for improvement, applying mathematical reasoning.

It is vitally important to implement learning environments and the right strategies in educational institutions so that future graduates' school performance increases and that they in turn can apply theoretical knowledge in everyday contexts.

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Gamification in the field of initial music education. An innovative teaching-learning strategy

La ludificación en el ámbito de la educación musical inicial. Una estrategia de enseñanza-aprendizaje innovadora

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Abstract

This paper presents an alternative way of approaching music education for kids in initial education using gamification as a strategy. Gamification is an educational tool of relatively recent creation, which is based on game theory in the computer field, but in recently days it has been easily adaptable to the classroom and especially in early childhood musical education. This research aims to identify the constituent elements of a gamification based on Marczewski's proposal, to later devise a gamification plan in the field of initial music education. To achieve this objective, an analysis of the main constituent elements of gamification is carried out, with the purpose of structuring them in a way that allows the creation of educational planning with didactic sequences based on the project method, being quite innovative in the musical educational field.

Intrinsic motivation, Gamification, Musical education

Resumen

Este artículo presenta una forma alternativa de abordar la educación musical para niños en educación inicial utilizando la Ludificación como estrategia. La ludificación es una herramienta educativa de creación relativamente reciente, que se basa en la teoría de juegos en el ámbito informático, pero que en los últimos tiempos se ha ido adaptando fácilmente al aula y especialmente a la educación musical infantil. Esta investigación pretende identificar los elementos constitutivos de una ludificación a partir de la propuesta de Marczewski, para posteriormente idear un plan de ludificación en el ámbito de la educación musical inicial. Para lograr dicho objetivo se realiza un análisis de los principales elementos constitutivos de la ludificación, con la finalidad estructurarlos de forma que permitan la creación de planeaciones educativas con secuencias didácticas con basadas en el método de proyectos, siendo bastante innovadora en el ámbito educativo musical.

Motivación intrínseca, Ludificación, Educación musical

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Introduction

One of the keys to teaching is to understand the way people learn so that education adapts to them and so that they can develop meaningful learning. Among the many strategies employed, we find that of gamification, which has been developing over the last decade with the desire to be more relevant, in response to the criticisms that arose at the time of this technique due to its marketing origin. However, it is structured in such a way as to generate favourable environments with appropriate stimuli in a regulated space, on the other hand, intrinsic motivation is especially encouraged, without underestimating other types of motivations or intentions when designing gamification.

One of the benefits of this strategy is its use in the field of music education, because it becomes quite relevant to attend to music learners in the initial stages, especially during the first phases of school education, whether in pre-school or primary school.

In this sense, at the end of the paper, a gamification programme is presented with an example so that its use can be appreciated, giving teachers the possibility of creative development towards new forms of interaction with pupils.

1. Justification

Approximately in 2010, a wave began to use games as an educational strategy in contexts that are not commonly used to be played, which is called gamification; this proposal arises with the definite purpose of increasing participation and taking advantage of the motivation of users to carry out activities that allow some change in the participants; in a certain way the intention is that the work or activities have a certain proportion of fun (Chitroda, 2015).

However, the observation of play as an educational element is not new, although it has accompanied us throughout history; we owe the study to identify the first contributions on the importance of play in the field of education to psychology, and it is from the second half of the nineteenth century that the first theories on play were identified.

Spencer (1855), for example, considered it as the result of an excess of accumulated energy, allowing it to "spend" surplus energy; on the other hand, Lazarus (1883), argued that individuals tend to perform difficult and laborious activities that produce fatigue, from which they rest by performing other activities such as play, which allows and produces some relaxation. By 1904, Hall's theory already showed the link between play and human cultural evolution, while reud saw it as part of the satisfaction of instinctive impulses (erotic or aggressive), with the need for expression and communication of life experiences and the emotions that accompany these experiences. Piaget, from 1932 to 1966, emphasised the importance of play in developmental processes on many occasions, both theoretically and in clinical observations; he also based his research on moral development on play.

Similarly, Vygotsky, at the beginning of the 20th century, pointed out that play allows the development of conceptual behaviour guided by ideas, where the imaginary situation alters the child's behaviour, defining itself through its actions (Chamorro López, 2010).

The interesting thing about gamification is that it arises as a consequence of the use of computer technology, being Richard Bartle from the University of Essexx who, in 1978, started with multiplayer experiences through the MUDI programme that used Telnet. By 1980, Thomas W. Malone, a professor at MIT, worked on how children can learn through play and included elements of Intrinsic Motivation.

It was not until 2004 that Games for Change was created, as a platform for different games that helped people understand the complexities of social conflict and, in turn, aimed to drive social change and humanitarianism within their communities.

But the term gamification itself was not used until 2003 thanks to Nick Pelling, a British programmer and inventor, only to take off in early 2010 when Jesse Schell and Jane McGonigal, who viralised the concept of gamification, got people thinking about using it for various aspects of life.

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While its approach emerges as an element of technology and remains its key enabler, it has generated strategies that allow for its structured development in education beyond the virtual environment, enabling new ways of harnessing the power of educational technology to maximise the progress of educational objectives and achieve learning success. (Chitroda, 2015).

A more current definition of gamification is provided by Kevin Werbach (2014) who defines it as: '"The process of making activities more game-like' focuses on the crucial space between the components that make up games and the holistic experience of gamefulness". ['"The process of making activities more game-like' focuses on the crucial space between the components that make up games and the holistic experience of gamefulness" (p. 266)." (p. 266). It is necessary to point out that, in accordance with this definition, gamification will be approached as a trigger for an educational intentionality, exploring it as a strategy within a game-based learning proposal. That is to say, to take advantage of its possibility of being used outside the classroom, however, not forgetting that it is possible to consider it as a ludic tool in which games have the possibility of rewarding the players themselves with their own satisfaction and pleasure of being in the game, taking for this purpose the RAMP theory of motivation, by Andrzej Marcewski: Relationship, Autonomy, Mastery and Proposal; and the 8 Kinds of Fun, by Marc Leblanc: Physical Sensation, Community, Fantasy, Discovery, Narrative, Expression, Challenge and Submission. (Net-Learning, 2015; Toledo Inclán, 2020*).*

Although some authors once considered gamification outside of game-based learning, due to its utilitarian function in the area of marketing and the business world, exposing various criticisms mainly as an element of promoting consumption, it is true that the development has also been addressed outside this commercial field, and even as structuring strategies for creating games that do not necessarily make use of technology, but of the design of the gamification process (Bagost, 2011; Robertson, 2010).

In any case, these first analyses need to be considered, especially if the aim is to promote a critical educational scheme, with the strategic possibility of creating game proposals focused on the development of educational processes. It is also imperative to note that even Marczewski is once held responsible for the prejudices regarding gamification by focusing on "behavioural changes" or "human-centred design" from marketing (2018, p. 13).

As a consequence of this innovative approach, strategies in the field of education were outlined in the last decade, and in 2022 researchers Lampropoulos, Keramopoulos, Diamantaras and Evangelidis from the International Hellenic University, conducted an analysis of 670 articles from 5 databases (Scopus, Web of Science, Google Scholar, IEEE, and ERIC) on gamification in education; These articles found overall positive behavioural, attitudinal and psychological changes and increased student engagement, motivation, active participation, knowledge acquisition, focus, curiosity, interest, enjoyment, academic achievement and learning outcomes, with teachers also positively evaluating its implementation. (Lampropoulos, Keramopoulos, Diamantaras, & Evangelidis, 2022).

It is necessary to reiterate that gamification is a strategy that allows the use of play in activities that are not commonly thought of as games, hence its importance as a strategy that generates pedagogical games. Lawley, a professor of games and interactive media at the Rochester Institute of Technology (RIT), notes that, when properly implemented in an educational way, "Gamification can help enrich educational experiences in a way that students will recognise and respond to. [Gamification can help enrich educational experiences in a way that students will recognise and respond to".] (Deterding, 2012).

Within the literature on educationally focused games, it can be observed that they are most successful when they have elements such as: freedom to make mistakes, quick feedback, some progression and an accompanying story (Stott & Neustaedter, 2013).

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In recent years, one of the most important focuses for the gamification process has been to work with the motivation of game participants, understanding that it is operating in two different ways, as intrinsic motivation and extrinsic motivation.

Intrinsic motivation is the natural tendency to seek and overcome challenges as personal interests are pursued and skills are exercised, it is because of this that no incentives (or punishments) are required because the activity is rewarding in itself, and it is because of the focus on this motivation that less interest has been given to the point system in current gamification, as it catered to extrinsic motivation, which arises to obtain something external, points, grades, etc. The essence of these types of motivation is the locus of control of the cause (the location of the cause), whether internal or external (Woolfolk, 2014).

2. Problem statement

One of the most important interests in addressing the issues of education is to understand how people learn, education is therefore a tool for acquiring knowledge that over the years has tried to understand and seek strategies that are consistent with the characteristics of human beings. In this interest in understanding the significance of knowledge, we find ourselves in the work of Ausubel who, from cognitivist psychology, deals with the description of the principles that converge with the idea of organisation and formation of the human mind, and how these reach different states of consciousness.

The perception of the underlying cognitive processes is achieved with learning that is internalised by transforming the learner's mental structures, thus, the main objective of his theory was to present how human beings learn, and consequently, Ausubel points out that meaningful learning requires both the attitude of meaningful learning and the presentation of potentially meaningful material; two basic conditions derive from the latter: firstly, that the material is related in a plausible, reasonable and non-random way to an appropriate and relevant cognitive structure and, secondly, that the learner's cognitive structure contains anchoring ideas with the new material (Ausubel, 2002).

While each person's cognitive structure is unique and therefore meanings are also unique, it is important to note that, within that uniqueness, Ausubel (1983) identifies three main types of learning, which are:

1. Representational learning. - This allows the assignment of meaning to particular symbols (usually words) and "occurs when arbitrary symbols are equated in meaning with their referents (objects, events, concepts) and signify to the learner whatever meaning their referents allude to" (Sullivan & Ausubel, 1983, p. 46).

2. Concept learning. - This learning enables the acquisition of new knowledge, and is whereby symbols take on meaning through the understanding of experiences through construction and mental projections that end up being expressed in words.

3. Proposition learning. - This involves a combination and relationship of several words each constituting a unitary referent (component), to be subsequently combined in such a way that the resulting idea is more complex than the simple sum of the meanings of the individual component words, producing new meanings assimilated into the cognitive structure.

As can be seen, it is in these basic learning processes that all other learning processes are derived by combining and linking them together, especially if there is a learning attitude and the material in turn is meaningful, So the question arises of how to bring meaningful learning into the classroom for music students? To answer this question, we propose to draw on the work of Andrzej Marczewski (2018), who proposes a scheme of gamification, game thinking and motivational design, which mainly employs intrinsic motivation by identifying people's main motivations. He personally defines gamification as "The use of game design metaphors to create more game-like and engaging experiences" (p. 13). (p. 13).

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With this information we set out the objective of identifying the constituent elements of gamification based on Marczewski's proposal, in order to subsequently devise a gamification plan for early music education in pre-school or primary school. In this sense, Marczewski proposes the following scheme for approaching gamification:

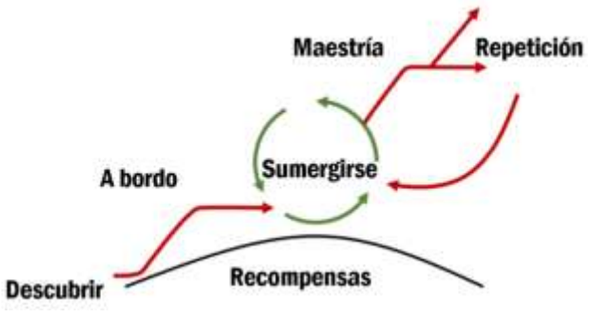

Figure 1 User journey framework for gamification (Marczewski, 2018, pág. 133)

But for a student/player to be able to follow this path of gamification, it is required to comply with certain mechanisms that allow to understand the procedures of the game, what makes it fun, what are the stories that will accompany it, the materials or technology that will be placed to make it happen and finally, the aesthetics of the environment that will allow the greatest impact (Schell, 2019), the aesthetics of the environment that allows the greatest impact (Schell, 2019), as well as what the players must think or mentally elaborate and the ethical aspects immersed in the game, the latter leads us to reflect on the deep reason why a game is proposed and where we want to get to with it (Marczewski, 2018).

3. Methodology developed

For this research, documentary research on gamification was carried out in an attempt to find proposals that could be used outside the field of computers, that is to say, that although its origin had been in computing, it could be used in multiple fields with the aim of making it a teaching-learning strategy for any educational environment and, above all, that would allow its inclusion in a planning scheme for children's music education. To this end, a selection of texts was made, discriminating against those that did not meet the established criteria, i.e. those that required the use of digital technology as a compulsory strategy.

Marczewski was the main reference, however, his proposal was modified with contributions from other researchers in order to consequently present a relevant alternative in the field of children's music pedagogy.

4. Motivation

Undoubtedly, motivation takes on a transcendent importance in this proposal, and the fact that gamification has made it possible to achieve a significant attitude, as shown in a research on the results of various publications that analysed the application of gamification at the baccalaureate level:

The most repeated in gamification works is the increase in motivation (Alarte-Hernández et al., 2021; Fernandez-Río et al., 2020; Monguillot et al., 2015; Navarro et al., 2017) coinciding with the results of Apóstol (2013) where they stated that gamification positively affected motivation.

Within motivation, both intrinsic motivation and extrinsic motivation are affected by gamification (Fernández-Río et al., 2020; Monguillot et al., 2015).

Extrinsic motivation is affected by game elements such as rewards or progress bars according to Malone & Lepper (1987). Often these classifications favour the social factor (Deci & Ryan 1985), although authors such as Fernández-Río (2020), the markers are not public, to avoid generating this competition with the rest of the students. Even so, it is observed that in the rest of the studies extrinsic motivation increases (Alarte-Hernández et al., 2021; Monguillot et al., 2015). (López Quero, 2022).

As can be identified, motivation is one of the elements that most manages to promote gamification, however, this starts from certain considerations, i.e., trying to enhance intrinsic motivation and thereby identify how to propose gamification, for this identifies three layers of motivation:

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Figure 2 Own creation based on the three layers of motivation. (Marczewski, 2018, pág. 74)

Humanistic approaches have introduced the notion of growth as a key element. They argue that within every human being there is an intrinsic motivation to expand one's own capabilities and develop inherited talents. This innate motivation is shared by all individuals, although certain circumstances may influence its manifestation, either fostering or hindering it (Elizalde, Martí Vilar, & Martínez Salvá, 2006).

In the graph, the base shows the basic needs of the human being, those that are minimally required to achieve a certain fulfilment in order to obtain better experiences; although these have been repeatedly criticised, in general they allow us to think of those minimum conditions of a human being to be satisfied in order to achieve an adequate development in life. On the other hand, intrinsic motivations are thought of as those that are inherent to the participating subject, and in Marczewski's proposal, they allow, through their identification, to delineate certain types of players to whom different activities are offered.

5. Types of players

It is very important to point out that gamification, in order to meet the motivational requirements of those to whom gamification is proposed, it is necessary to identify who they are and what their interests are in general, which will lead to a more transcendent proposal.

– Philanthropists are motivated by purpose and meaning. This group is altruistic, wanting to give to others and enrich the lives of others in some way, without expectation of reward.

– Socialisers are motivated by relationship. They want to interact with others and create social connections.

– Achievers are motivated by mastery. They are seeking to acquire knowledge, learn new skills and improve themselves. They want challenges to overcome. Eduardo Toledo (2020) translates these terms into Spanish as conseguidores who are motivated by mastery.

– Free spirits are motivated by autonomy and self-expression. They want to create and explore.

– Disruptors are motivated by change. In general, they want to disrupt their system, either directly or through other users to force positive or negative change.

– Gamers are motivated by extrinsic rewards. They will do whatever it takes to collect rewards from a system and not much else. They are in it for themselves.

These six types of people (gamers) are engaged by specific motivations, identifying in the first four types of people, connections with interests based on their intrinsic motivation, while in the case of disruptors by four disruptive sub-motivations (Afflicters, Destroyers, Influencers and Innovators), and in the case of gamers four extrinsic sub-motivations (Egoists, Consumers, Networkers and Exploiters). Marczewski arranges them as follows in a diagram for further visualisation.

Figure 3 Own creation based on the scheme of user types (Marczewski, 2018, pág. 115)

Each of these users or players will be interested in certain activities, and these activities will allow gamification to maintain an optimal development without generating stress or boredom, something that is called fluency. Each of the motivations generates different behaviours, so it will be necessary to reflect, depending on the type of users, which ones we will try to encourage and also what they are expected to stop doing..

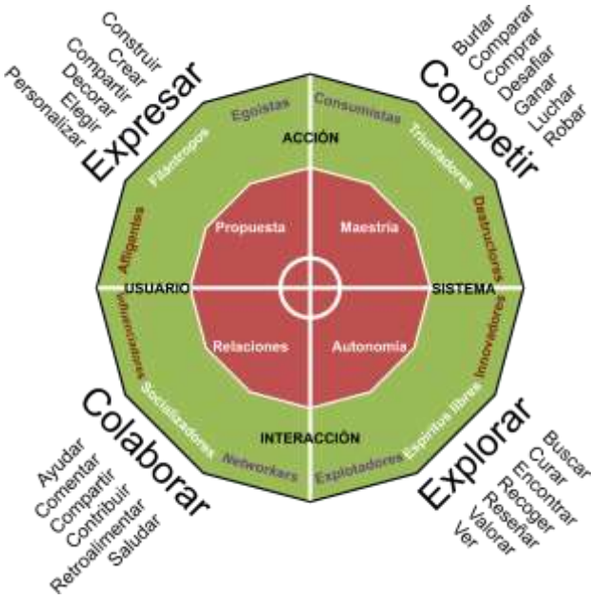

Figure 4 Own creation, including Marczewski's previous graph of users and their behaviour

6. Experiences

For this purpose, some pleasant experiences are going to be included transversally in the project, taking into account the 8 types of fun according to Hunicke, Le Blank and Zubek (2004), which are:

1. Sensation: Play as sensory pleasure.
2. Companionship: Play as a social framework.
3. Fantasy: Play as fantasy.
4. Discovery: Play as unknown territory.
5. Narrative: Play as drama.
6. Expression: Play as self-discovery.
7. Challenge: Play as obstacle course.
8. Submission: Play as a pastime (Hunicke, LeBlanc, & Zubek, 2004).

Likewise, we find such pleasant experiences in the form of cards created by Ferrán Altarriba and shared by Toledo Inclán.

Figure 5 Pleasant experiences (Altarriba, Ferrán en Toledo Inclán, 2020)

In order to transmit these experiences, the best strategy is through the creation of a theme that describes a leading situation and that allows the creation of the environment or atmosphere where gamification takes place and makes known the Experiences that are going to be proposed, either the Activities or behaviours according to the Motivations of each one of the players, as well as the Dynamics that will take place at the moment of the game and the Mechanics or ways in which they will be carried out.

The story that is made will provide an introduction to the game and the possibilities of the game, so that the game can be made in a personal or communal way and, if necessary, show the rewards that are given for the achievements.

The general structure of a narrative is: the introduction, the challenge, the transformation and the resolution. It is important to consider that the narrative does not have to be linear and that several characters should be involved, thus inviting many possibilities for the completion of the game. An important issue to point out is that the cartoon has meaningful choices for the members, so that they become as much immersive as possible, it is important to consider that every decision has consequences and, on the other hand, although the cartoons are fictional and from a fantasy world, it is necessary that they remain tied to the reality we want to promote, so that the players manage to understand this educational interaction without problems (Marczewski, 2018).

7. Dynamics

One of the issues sought within gamification is to convert what motivates them into actions through the use and interaction between people, through fictitious situations, posed with specific objectives previously established. In this sense, the generation of dynamics is proposed with the possibility of generating participatory experiences, that is, based on what the participant feels and lives, and also if we look at it as a dynamic that is carried out with others among peers:

It is an excellent way of community integration, as well as an effective procedure of social education and cooperation. There is a strong satisfaction in participation, communication and exchange (Ortega, 2016).

For this purpose, the 16 desires of Steven Reiss (2002) are used, the idea is to ensure that the dynamics designed have a certain pleasure for the participants, for Reiss, pleasure is the by-product of achieving what we want, it is not the end of the desire, as an example he gives that, in the case of health personnel. For this person the goal of experiencing pleasure is not created in the desire to help patients; rather, altruism prompts them to make sacrifices for their patients. Thus, we have certain desires such as the desire for tranquillity, social contact, romance, among others that lead us to generate a proposal and story in the games.

The dynamics seen as a set story that gives structure to the gamification, these fall on the fact of having the players interested and connected with their motivations by establishing the context and means of development within the gamification, we could work the dynamics as the structure of the theme of the gamification. Reiss (2002) describes them as follows:

1. Acceptance: the need to be appreciated.
2. Curiosity, the need to acquire knowledge.
3. Eating, the need to eat.
4. Family, the need to care for children.
5. Honour, the need to be true to the customary values of an individual's ethnic group, family or clan.
6. Idealism, the need for social justice.
7. Independence, the need to be distinct and self-reliant.
8. Order, the need for prepared, established, conventional environments.
9. Physical activity, the need for out-of-body work.
10. Power, the need to control the will.
11. Romance, the need for mating or sex.
12. Saving, the need to accumulate something.
13. Social contact, the need for relationship with others.
14. Social status, the need for social significance.
15. Reassurance, the need to be safe and secure.
16. Revenge, the need to strike back at another person (Reiss, 2002).

Similarly, Toledo Inclán shares graphically the sixteen dynamics with Ferrán Altarriba's designs in which the action to be undertaken is described.

Figure 6 16 wishes (Reiss, Steven en Toledo Inclán, 2020)

8. Mechanics

Likewise, we have to consider important the mechanics, which are the implementation of the dynamics, that is to say, those situations that will allow us to generate activities that will encourage intrinsic motivation, to which we could add some mechanics of extrinsic motivation or disruption that allow us to keep people active who sometimes are not so intrinsic, but, in gamification, we will try to encourage or stimulate them towards intrinsic activities or behaviours. Marczewski proposes the following mechanics in which we are going to promote the behaviours to be stimulated.

Intrinsic

1. Socialisers:

a. Guilds/Teams. Let people build close-knit guilds or teams. Small groups can be much more effective than large, sprawling ones. Create platforms for collaboration, but also pave the way for team competitions.

b. Social networking. Allow people to connect and socialise with an accessible and easy-to-use social network. It can be more fun to play with other people than to play alone.

c. Social status. Status can generate greater visibility for people, creating opportunities for new relationships. It can also feel good. It can make use of feedback mechanisms such as leaderboards and certificates.

d. Social Discovery. A way of finding people and being found is essential for building new relationships. Matching people based on their interests and status can help people start interacting.

e. Social pressure. People often do not like to feel like outsiders. In a social setting, this can be used to encourage people to be like their friends. It can be demotivating if expectations are unrealistic.

f. Competition. Competition gives people the opportunity to prove themselves in front of others. It can be a way to earn rewards, but it can also be a place where new friendships and relationships are born.

2. Free spirits:

a. Exploration. Give your free spirits space to move and explore. Consider that they will want to find the boundaries so give them something to find.

b. Branching options. Let the user choose their path and destination. From multiple learning paths to responsive narratives. Remember, the choice must be (or at least feel) meaningful to be most effective and appreciated.

c. Easter eggs. Easter eggs are a fun way to reward and surprise people just for a glimpse. For some, the harder they are to find, the more exciting it is!

d. Unlockable/rare content. Add to the sense of self-expression and value by offering unlockable or rare content for free spirits to use. Linked to Easter eggs and exploration, as well as achievements.

e. Creativity tools. Allow people to create their own content and express themselves. This can be for personal benefit, for pleasure or to help others (learning materials, levels, equipment, FAQs, etc.).

f. Personalisation. Give people the tools to personalise their experience. From avatars to the environment, allow them to express themselves and choose how they will present themselves to others.

3. Achievers:

a. Challenges. Challenges help keep people engaged, testing their knowledge and allowing them to apply it. Overcoming challenges will make people feel that they have earned their achievement.

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b. Certificates. Unlike general rewards and trophies, certificates are a physical symbol of mastery and achievement. They carry meaning, status and are useful.

c. Learning/New Skills. What better way to achieve mastery than to learn something new? Offer your users the opportunity to learn and expand.

d. Quests. Quests give users a fixed goal to achieve. Often made up of a series of linked challenges, multiplying the sense of achievement.

e. Levels/Progression. Levels and objectives help map a user's progression through a system. It is as important to see where you can go as it is to see where you have been.

f. Boss battles. Boss battles are an opportunity to consolidate everything you have learned and mastered into an epic challenge. It usually signals the end of the journey and the beginning of a new one.

4. Philanthropists:

a. Meaning/Purpose. Some just need to understand the meaning or purpose of what they are doing (epic or not). For others, they need to feel that they are part of something bigger than themselves.

b. Caring. Caring for others can be very rewarding. Create roles for administrators, moderators, curators, etc. Allow users to take on a parenting role.

c. Access. Access to more functions and capabilities in a system can give people more ways to help others and contribute. It also helps them feel valued. More meaningful if earned.

d. Collect and trade. Many people love to collect things. Offer them a way to collect and trade items in your system. It helps build relationships and feelings of proposition and value.

e. Gift/Share. Allow giving away or sharing items with others to help them achieve their goals. While it is a form of altruism, the potential for reciprocity can be a strong motivator.

f. Knowledge sharing. For some, helping others by sharing knowledge with them is its own reward. Develop people's capacity to answer questions and teach others.

g. Extrinsic (Use sparingly if working with adults or to maintain attention in long games).

5. Gamers:

a. Points / Experience Points (XP). Points and XP are feedback mechanisms. Can track progress, as well as be used as a way to unlock new things. Reward based on achievement or desired behaviour.

b. Physical. Rewards/Rewards. Physical rewards and prizes can promote a lot of activity and, when used well, can create engagement. Be careful to promote quantity over quality.

c. Leaderboards / Ladders. Leaderboards come in different forms, most commonly relative or absolute. Commonly used to show people how they compare to others and for others to see them. It is not for everyone.

d. Badges / Achievements. Badges and achievements are a form of feedback. Reward people for their achievements. Use them wisely and meaningfully to make them more appreciated.

e. Virtual economy. Create a virtual economy and allow people to spend their virtual currency on real or virtual goods. Examine the legalities of this type of system and consider the long-term financial costs!

f. Lottery / Gambling. Lotteries and games of chance are a way to win prizes with very little effort on the part of the user. You have to be involved in it to win!

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Disruptive (To promote changes in the environment, use wisely).

6. Disruptors:

a. Innovation Platform. Disruptors think outside the box and the boundaries of their system. Give them a way to channel that and you can generate great innovations.

b. Voting/Voice. Give people a voice and let them know they are being heard. Change is much easier if everyone is on the same page.

c. Development tools. Think about modifications instead of hacking and breaking. Allow them to develop new add-ons to improve and develop the system.

d. Anonymity. If you want to encourage total freedom and lack of inhibitions, allow your users to remain anonymous. Be very, very careful as anonymity can bring out the worst in people!

e. Light touch. While you must have rules, if you are encouraging disruption, apply them with a light touch. See how things develop before you jump in. Be attentive and listen to user feedback.

f. Anarchy. Sometimes you just have to burn it all down and start again - sit back, throw the rule book out the window and see what happens! Consider running short "no rules" events (2018, pp. 252-259).

Feedback

Within education, but even in games, doing an activity in a repetitive way without the possibility of improvement or innovation ends up becoming boring and even a nuisance, and an activity could not be thought of as educational if there are no possibilities for feedback in it, therefore, it is important to consider that the proposal must involve an interesting challenge where patterns of recognition of progress are established.

For this the process must have an assurance of learning with feedback at all times in order to adjust what is necessary, therefore, an environment must be generated that allows the possibility of failure; This environment is called in gamification as a magic circle and, finally, to allow that after achieving the fulfilment of a challenge, to give a sense of gratification or reward for the effort spent towards that conclusion to each student. Here it is important to note that the conclusion invites us to try to meet a new challenge with a higher level of difficulty than the one previously used, the key is to maintain the enthusiasm to achieve new achievements (Marczewski, 2018). Graphically we observe this feedback scheme with the following figure:

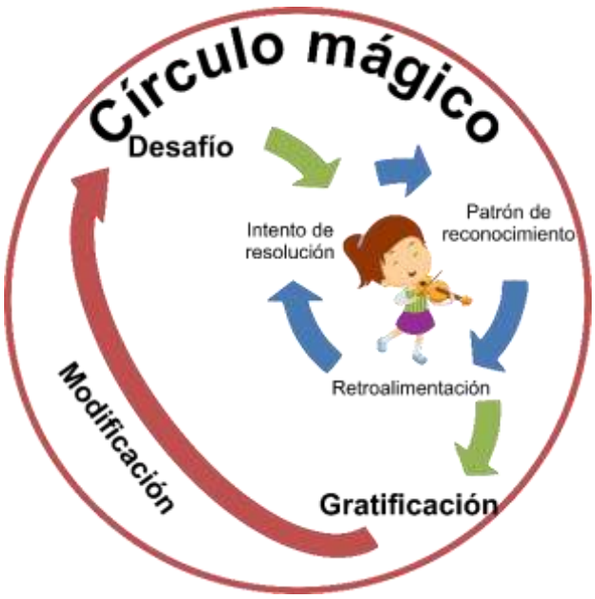

Figure 7 Own creation based on the magic feedback loop (Marczewski, 2018, pág. 179)

After this broad approach to each of the constituent elements of gamification, it now remains to describe the planning scheme of gamification in order to verify how each of these elements interacts with a specific topic to be addressed.

Playification scheme, approach to the educational approach

The gamification scheme is a mixture of Marczewski's (2018) proposal and Gojko Adzic's (2012) mapping presented by Toledo (2020) to which we have adapted it for use as a planning tool. This outline is intended to provide the following elements for those who intend to implement gamification.

According to the following table, it is possible to understand the structure of gamification:

Defining the educational purpose:	A detailed example is given in table 2.
What kind of players will interact?	
- Philanthropists - Socialisers - Achievers - Free spirits - Disruptors - Gamblers	
¿ What experiences will they be immersed in, the use of emotions? Theme and narrative that builds the atmosphere: 8 types of fun.	
1. Sensation: Play as sensory pleasure. 2. Companionship: Play as a social framework. 3. Fantasy: Play as fantasy. 4. Discovery: Play as unknown territory. 5. Narrative: Play as drama. 6. Expression: Play as self-discovery. 7. Challenge: Play as obstacle course. 8. Submission: Play as pastime The narrative of play: - Introduction - The challenge - Transformation - The resolution	
¿ Which activities (behaviours) will be encouraged according to the type of players? RAMP:	
Relationships: Collaborate (Help, comment, share, contribute, nurture, greet). Autonomy: Explore (Seek, Curate, Find, Collect, Review, Assess, View). Mastery: Compete (Outwit, Compare, Buy, Challenge, Win, Fight, Steal). Proposition: Express (Build, Create, Share, Decorate, Choose, Customise, Personalise).).	
¿ What are the working dynamics, i.e. the actions during the game? 16 wishes:	
Acceptance Curiosity Eating Family Honour Idealism Independence Order	Physical activity Power Romance Saving Social contact Social status Peace of mind 16.Revenge
¿ What mechanics will be used with respect to the type of players, is that allowed to perform:	
Intrinsic Socialisers: a. Guilds/Teams b. Social network c. Social status d. Social Discovery e. Social Pressure f. Competition. 2. Free spirits: a. Exploration b. Branching options c. Easter Eggs d. Content desbloqueable/raro Herramientas de creatividad c. Personalisation 2. Successful: a. Challenges. b. Certificates c. Learning/New Skills d. Missions e. Levels/Progression f. Boss battles. 3. Philanthropists:	l. Meaning/Purpose m. Care n. Access o. Collect and trade p. Gift/Share q. Knowledge sharing Extrinsic 2. Players: a. Points / Experience Points (XP) b. Physical rewards / Prizes c. Leaderboards / Ladders d. Badges / Achievements e. Virtual economy f. Lottery / Gambling Disruptive 3. Disruptors: a. Innovation Platform b. Voting/Voice c. Development Tools d. Anonymity e. Light touch f. Anarchy

Table 1 Components of gamification.

With this information, we consider that the graphical outline of gamification is as follows:

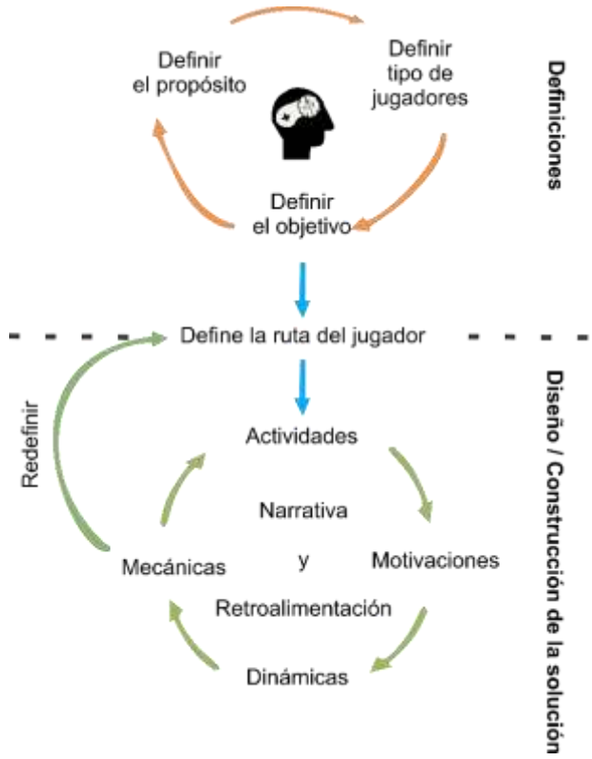

Figure 8 Structure of gamification, own creation based on (Marczewski, 2018, p. 271)

Results

With the information presented above, we show a sample of school gamification planning, as an example, as follows:

Title: the guitar and the family

LEAD GUITAR	EDUCATOR:	BIMESTER OF THE COURSE: 2	NUMBER OF SESSIONS: 6	START: END:
What am I going to do, how am I going to do it, who am I going to do it for, where am I going to do it, and with what resources?	Explore the strings of the guitar with the aim of achieving a good position and use of the index and middle fingers of the right hand. The book The Little Guitarist's Notebook by Nadia Borislova, the three songs on pages 79, 80 and 81, will be used for this purpose. The proposal will be focused on Girls and boys guitarists of the initial guitar course. Basic education of phase 3. Developing in face-to-face classes with the intention of practising at home. Having as necessary resources their guitar, music stand and bench, as well as the respective book.			
What do we want students to learn and achieve, what is the plan to achieve it, how do we make learning more effective, and how do we evidence and assess learning achievement?	The aim is to encourage the proper use of the right hand with the index and middle fingers, having a good sound and location of the guitar strings while taking care of their position. In order to achieve this, a process will be carried out with each of the strings as they pluck and interchange the sounds of the guitar with the lyrics of the songs. In order to achieve effectiveness, special attention will be paid to the way of interpreting, avoiding normalising mistakes during the performance, going from a slow speed to a faster one, maintaining a constant rhythm. The strategy of evidence is through a presentation in front of their classmates.			
Describe the type of players:	It will depend on the group in question. It is recommended to use the motivation assessment in the league: https://www.gamified.uk/UserTypeTest2023/user-type-test.php For our case, we will try to encourage the intrinsic motivations of Socialisers and Achievers essentially.			
What experiences they will be immersed in, the use of emotions. Theme and narrative that builds the	Once Vlad had gone out to the countryside with his mother, his father and his grandmother. As usual they walked around trying to find new places, so they chose to take a path that led them to a space full of light, flowers and tinkling sounds, like little bells. Anita was so excited that she ran off without realising that she had entered an enchanted forest, so she suddenly found			

atmosphere: 8 types of entertainment..	herself alone. She started to get scared, but through the leaves she heard a magical voice saying: "Don't worry, just sing the songs while you play this magic guitar". Fortunately Anita had started her music lessons so she quickly set about the task of playing them. There appeared some sheet music in gold leaf and a large guitar that seemed to play by itself. In the background of the forest he could see the silhouettes of his mother, his father and his grandmother. As he played the respective pieces, their silhouettes became more and more obvious and shiny. If he made a mistake, they would disappear again. Likewise, he noticed that while he played the guitar, many little animals from the forest came to listen to him play and sing. The voice of the forest told him that he had not only to play, but to put all his heart into it. So in the end he managed to play the songs perfectly and everyone could laugh. The voice of the forest brought them a blanket with food and lots of goodies that they could enjoy for the rest of the afternoon.
Which activities (behaviours) will be encouraged according to the type of players: RAMP	Mastery: Challenging oneself, to achieve the right interpretation. Relationships: Collaborate through their personal contribution to the music of the guitar and singing, nurture other classmates to excel and discuss ideas to achieve together to overcome the challenge of managing to appear to the parents. Drawings will be used in the score to indicate the progress made in making the parents appear, real photos can be used..
What are the working dynamics, i.e. the actions during the game. 16 wishes.	Acceptance, Eating, Curiosity, Family, Social contact. Each child will practice in class with collaborative presentations, so that each of the pieces is covered in a maximum of two weeks. The teacher will place the silhouettes of mum, dad and grandma on the blackboard or another child, depending on the interpretation. The listeners will be the other children in the class simulating the animals of the forest, while the voice of the forest will be the teacher. At the end of the last performance, some small chocolates will be distributed.
What mechanics will be used with respect to the type of players, what they are allowed to do.	Socialisers: Discovery and social pressure. Achievers: Learning new skills and progression scheme. At the end of the second session, after several rehearsals, a staging of the story will take place. At the end of the second session, after several rehearsals, a staging of the story will be carried out. The children are invited to motivate their classmates to meet the challenge and, above all, to feel listened to by the others..

	Learning activities and organisation of learners	Core product and developments	Essential resources	Session
Start	Presentation of the play, raising awareness and reminder of beats, musical figures and notes. Individual and group rehearsal of the piece.		Lectern, bench, guitar and book	1 y 2
Development	Individual rehearsal of the piece and performance practice in front of others.	First attempt to present the first piece.	Idem.	2 y 3
	Individual rehearsal of the piece and performance practice in front of others.	First attempt to present the second piece.	Idem.	3 y 4
	Individual rehearsal of the piece and performance practice in front of others.	First attempt to present the second piece.	Idem.	4 y 5
Conclusions	Dress rehearsal, group participation.		Idem.	6
	Presentations and participation in front of the other students.	Presentation of the pieces with contributions from classmates.	Idem.	6

Heading:

Indicators	Preformal	Receptive	Resolutive	Self-employed	Strategic
1.- rhythmic accuracy and fluency	No rhythmic precision or fluency.	Many difficulties in keeping the pulse of the work. The performance is constantly interrupted, eliminating any cohesion in the musical discourse. Rhythmic sequences lack precision.	He finds it difficult to adjust to the tempo of the work, often getting ahead or behind the tempo. The interpretation is insecure, with three or more pauses interrupting the musical discourse. Lacks some precision in the reproduction of rhythmic sequences.	He keeps the pulse of the work quite well, although he occasionally breaks off, gets ahead or falls behind in tempo. Reproduces rhythmic sequences accurately most of the time.	Keeps the pulse of the work perfectly without interruptions and keeps to the tempo. Reproduces the rhythmic sequences accurately.
2.- melodic/harmonic accuracy.	No melodic or harmonic precision.	The interpretation of the melody or harmony (notes and/or chords) lacks precision throughout most of the work.	There is a lack of precision and security when interpreting the melody or harmony (notes and/or chords) in many moments of the work, but it tries to do so.	Interprets the melody or harmony (notes and/or chords) quite accurately and confidently throughout most of the work.	Interprets the melody or harmony (notes and/or chords) throughout the piece with complete precision and confidence.
3.- sound quality	No sound quality.	Sound is not controlled, lacks clarity and definition throughout most of the work.	The sound, in general, is poorly controlled, although some clarity and definition is achieved at times.	The sound is clear, defined and of good quality throughout most of the performance.	The sound is clear, defined and of high quality.
4.- attitude during performance and rehearsals.	No interest in it.	Little or very little concentration and attention during rehearsals and performance. Does not usually follow the teacher's indications.	Concentration and attention variable during rehearsals and performance. Sometimes follows the teacher's indications.	Fair amount of concentration and attention during rehearsals and performance. Teacher's indications are usually followed.	Great concentration and attention during rehearsals and performance.
5.- group performance	No bonding with peers.	Is totally focused on his/her role, ignoring the performance of the rest of the group.	Has difficulty interpreting his/her role and adapting to the group. Sometimes succeeds in doing so.	Most of the performance manages to fit in with the group, but is sometimes too focused on his/her role.	The teacher's instructions are followed at all times.

Table 2 Example of gamification for a music subject

Conclusions

As can be seen, this type of strategy allows music education for children in basic education to be approached in an active, immersive way, with stimulation of motivation and also with the use of creative strategies. Having educational materials focused on childhood is a great help, and gamification is a tangible possibility to empower them towards new possibilities by making educational processes an intrinsic part of a motivating game.

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Finally, with this structuring we realised that there is a great possibility of bringing gamification to the musical education field, and we also observed that, with the proposal shown, there is the possibility of future applications by linking the strategy with school music projects that are developed within the New Mexican School.

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Design and validation of an instrument to evaluate the implementation of STEAM with a focus on inquiry for learning the Solar System on elementary school

Diseño y validación de un instrumento para evaluar la implementación de STEAM con un enfoque en la indagación para el aprendizaje del Sistema Solar en educación primaria

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Abstract

The purpose of this article is to describe the steps for the design and validation of a measurement instrument. The importance of the analysis of the conceptual literature for the measurement of the variables, the calculation of validity through the Content Validity Coefficient through Validation by Expert Judgment and the calculation of the Reliability Coefficient of the instrument, through the Cronbach's alpha. As a methodology, the process for the construction of an instrument to measure psychoeducational variables was used, specifically explaining each of its seven phases. The results obtained indicate that the instrument has an excellent level of validity and agreement; as well as a very high level of reliability. It is concluded that there is a valid and reliable measurement instrument to measure the implementation of STEAM with a focus on inquiry for learning the solar system in primary education and that its application for which it was designed is suitable.

Reliability, Validation, STEAM, Inquiry, Elementary School, Measuring instrument

Resumen

El propósito de este artículo es describir los pasos para el diseño y validación de un instrumento de medición. Se resalta la importancia del análisis de la literatura conceptual para la medición de las variables, el cálculo de la validez a través del Coeficiente de Validez de Contenido mediante la Validación por Juicio de Expertos y el cálculo del Coeficiente de Confiabilidad del instrumento, a través del alfa de Cronbach. Como metodología se utilizó el proceso para la construcción de un instrumento para medir variables psicoeducativas, explicando puntualmente cada una de sus siete fases. Los resultados obtenidos indican que el instrumento presenta un nivel de validez y concordancia excelentes; así como, un nivel de confiabilidad Muy alto. Se concluye que se cuenta con un instrumento de medición válido y confiable para medir la implementación de STEAM con un enfoque en la indagación para el aprendizaje del sistema solar en la educación primaria y que es apta su aplicación para el que fue diseñado.

Confiabilidad, Validación, STEAM, Indagación, Educación Primaria, Instrumento de medición

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Introduction

In educational research, it is essential to define variables to study human behavior, through measurement instruments; Hernández and Mendoza (2018) define a variable as "a property or concept that can vary and whose variation is susceptible to being measured or observed […] and that can be recorded by a measurement instrument" (p. 52), for these authors, a measurement instrument is one that "records observable data that truly represent the concepts or variables that the researcher has in mind" (p. 228). For Best (1973), measuring instruments are like material objects through which data can be acquired to analyze them, in order to verify the hypotheses of a research (cited in Ruiz, 2013, p. 41).

The measurement instruments designed must have reliability, validity and objectivity; Reliability refers to the fact that, if the designed instrument is applied to the same individuals on several occasions, it should yield the same results, therefore, they will be coherent and consistent; Validity refers to the fact that the designed instrument must truly measure the study variable, this is achieved through content, criterion and construct validity; Objectivity refers to the understanding presented by the instrument designed for the people who administer, rate and interpret it (Hernández, Fernández and Baptista, 2010).

Some authors also consider within the validity of the instruments, validity by expert judgment, which consists of the review of the construct of the instrument, through qualified voices or group of experts on the subject (Hernández, Fernández and Baptista, 2010; Luna, 2015).

From STEM to STEAM

With the advancement in science and technology, pedagogical strategies have emerged that contribute to the promotion of these two areas in various countries, one of these is STEM from the acronym Science, Technology, Engineering and Mathematics created by the National Science Foundation (NSF), to train creative and critical people using technology (Pastor, 2017, cited in Robles-Moral et al., 2022).

In 2009, in the United States this teaching strategy was implemented through the interdisciplinarity of these fundamental areas for scientists and engineers, focused on solving technological problems. Currently, the Arts and Humanities have been added to these in this interdisciplinary proposal, adding the A to STEM, thus creating STEAM (Meza and Duarte, 2020; Perignat and Katz-Buonincontro, 2019, cited in Silva-Hormazábal et al., 2022).

Ortiz-Revilla, Greca and Meneses-Villagrá (2021) analyzed the effectiveness of integrated STEAM education, as a possible way to improve the development of skills in the primary education stage, responding didactically to the complexity of today's world, stating that the development of competencies requires a radical change in the way in which teachers and students conceive the teaching and learning processes, therefore, they propose that integrated STEAM education is one of the potentially most useful and highly beneficial methodological approaches for the acquisition of competencies. that the society of the 21st century demands.

Campos et al. (2018), state that STEAM allows students to get involved in their training, achieving significant learning for a globalized world that not only requires excellent technical preparation, but also allows future professionals to not only transform and transfer information in knowledge, but also that they can function in multidisciplinary teams, where they face with leadership, critical thinking and creativity the great challenges that arise today in the industry.

Inquiry Learning

Bevins and Price (2016) consider that inquiry learning helps develop research skills in students, have control over their learning, increasing their understanding and motivation towards scientific practice to address an increasingly complex real world. This pedagogical strategy allows the development of scientific competencies during the development of activities, such as "experimental design, interpretation of results and argumentation of ideas, answering questions about the process" (Fuentes et al., 2018, p. 575), encouraging the discussion of ideas among students to answer questions posed at the beginning of the activities.

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STEAM with a focus on Inquiry

One of the important characteristics of STEAM is that it is integrated with active methodologies to have better academic performance of students, therefore, the implementation of a curricular design based on STEAM, which proposes the solution of real problems, will allow the development of students' scientific creativity at an early age (Tran et al., 2021).

One of the approaches used to awaken students' interest in scientific vocations is inquiry learning, because students experience amazement when knowing and understanding the world around them (Gordón, 2001, cited by Vizcarra, 2022), for this, it is necessary to design didactic learning sequences from textbooks (Fuentes et al., 2018) so that students develop scientific vocations in natural science topics.

In Mexico, starting in August 2023, they implement the STEAM inquiry-based learning methodology within free textbooks, to develop scientific thinking in primary school students. It consists of 5 phases for the development of projects, 1) Introduction to the topic, 2) Research design, 3) Organization and structuring of the answers to the specific inquiry questions, 4) Presentation of the inquiry results, and 5) Metacognition (SEP, 2023).

Therefore, the researchers set out to design a measurement instrument to evaluate the implementation of STEAM with a focus on inquiry, based on the previous phases, adding the scientific vocation.

Methodology

The methodology to design and validate the measurement instrument was based on Ruiz's (2013), 7 phases for the construction of an instrument to measure psychoeducational variables: 1) determine the purpose of the instrument; 2) decide on the type of instrument to use; 3) conceptualize the construct; 4) operationalize the construct; 5) integrate the instrument; 6) carry out the pilot study; and 7) carry out the technical study.

Development of the phases

Phase 1. Determine the purpose of the instrument

In this phase, it was determined that the purpose of the instrument would be the evaluation of the implementation of the STEAM methodology with a focus on inquiry, through the activities developed in a didactic sequence where the interdisciplinarity of STEAM and the learning phases were identified by inquiry, following a specific objective of the research project.

Phase 2. Decide on the type of instrument to use

Once the purpose of the instrument was determined, it was decided that the type of instrument to be used would be a perception survey with responses under the Likert scale “Very Much, A lot, Regular, Little bit, Nothing”, its design was oriented towards the understanding of 5th grade students on elementary education, in a rural area of the City of Ocosingo, Chiapas, Mexico, using emojis that would draw attention and identify their feelings.

Figure 1 Instrument responses
Source: Research Images, 2023

Phase 3. Conceptualize the construct

The researchers conducted a review of the literature to measure the perception of primary school students in the implementation of STEAM with a focus on inquiry; however, some separate instruments were found that were analyzed, but it was determined to design the construct based on from the SEP textbook where they describe the phases of the STEAM inquiry-based learning methodology for learning the Solar System.

Phase 4. Operationalize the construct

From the conceptualization of the construct, being the implementation of STEAM with a focus on inquiry, the researchers established that each phase of the inquiry would create a dimension with its respective questions to study it, adding the dimension of scientific vocations.

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Dimension	Operational definition	Questions
Phase 1. Introduction to the topic	An introduction to the topic is made, through prior knowledge, identifying the problem to be solved and establishing the questions for the investigation (SEP, 2023).	1. How much do I know about our solar system?
		2. Do I know what are the characteristics of celestial bodies, that is, planets, moons, meteors, meteorites found in our solar system?
		3. Can I identify the different ways to study and analyze the celestial bodies of our solar system?
Phase 2. Research design	The development of the investigation is specified, answering the questions posed in the previous phase, explaining the data or information obtained (SEP, 2023).	4. When I researched our solar system, how clear was the information to look for?
		5. When I researched our solar system, how clear were I about the steps to follow to obtain the information?
		6. How much information did I research about the characteristics of the celestial bodies in our solar system?
Phase 3. Organization and structuring of the answers to the specific inquiry questions	Conclusions are constructed in relation to the established problem, analyzing, organizing and explaining the data obtained during the development of the investigation (SEP, 2023).	7. How well can I identify the shapes and colors of the celestial bodies in our solar system?
		8. Did I know what technology is used to study the celestial bodies of the solar system?
		9. How well can I differentiate between the different ways of studying celestial bodies, for example, with the naked eye, a home telescope, or a space telescope?
Phase 4. Presentation of the investigation results	The results are presented to the group, preparing proposals to solve the problem posed (SEP, 2023).	10. How much did I learn to handle the types of colors that exist and how to create them?
		11. Regarding the planet I built, how many characteristics and colors did I apply?
		12. Regarding the planet I built, how much did I learn about calculating distances to locate the planets in relation to the sun?
		13. How much did I collaborate as a team to build our giant solar system?
Phase 5. Metacognition	A reflection is carried out on the activities developed individually and collaboratively, as well as the achievements obtained and the difficulties encountered during development (SEP, 2023).	14. How much did I like researching information about our solar system?
		15. How much did I learn to differentiate the sizes and dimensions of the planets?
		16. How much did I learn to measure the distances between the sun and the planets?
		17. Did I like using art supplies to color my solar system work?
		18. How much did I enjoy building my telescope?
		19. When I presented my work to my colleagues, how satisfied did I feel?
		20. How pleasant was it to work with my colleagues?
		21. How much relevant and important information about our solar system did I learn?
Scientific vocations	The vocation of an individual can be influenced by the social environment in which he or she operates (Pantoja, 1992). The vocation in science and technology can be influenced by scientific education based on the contents of educational programs, since attitudes and skills are developed during their professional training (Vázquez and Manassero, 2009).	With the solar system work we did:
		22. How curious and interested am I in learning what celestial bodies exist in our solar system?
		23. How much do I observe the sky to see what is happening in space?
		24. How interested am I in learning about the professions that are dedicated to science and technology to study space?
		25. Did developing this project allow me to think about what I want to do when I grow up?
		26. How much would I like to use technology to build things?

Table 1 Operationalization of the construct
Source: Research data, 2023

Phase 5. Integrate the instrument

In this phase, the final instrument is integrated to determine its validity, the researchers used validity by expert judgment, through the Content Validity Coefficient of Hernández-Nieto (2011), with the participation of 3 educational research experts, where each of them evaluated the criteria: Relevance. The degree of correspondence between the item statement and what it is intended to measure; Conceptual clarity. To what extent the item statement does not generate confusion or contradictions; Writing and terminology. If the syntax and terminology used are appropriate for 5th grade students on elementary school; Scaling and coding. If the scale used in each item is appropriate and has been duly coded; and Format. The way the items and the instrument in general are presented.

The calculation of the Content Validity Coefficient of Hernández-Nieto (2011) is determined by the following formula:

$$CVC_t = \sum \left[\left[\frac{\sum x_i / J}{V_{mx}} \right] - P_{ei} \right] \left(1 / N \right) \quad (1)$$

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Where:

N = total number of questions in the instrument.
$\sum x_i$ = sum of the scores given by each judge to each question.
V_{mx} = maximum value of the scale used by the judges.
P_{ei} = probability of error for each question.
J = number of judges.

Using Microsoft Excel software, a Content Validity Coefficient of 0.91271 was obtained, placing it at an excellent level of validity and agreement.

Interpretation of the Content Validity Coefficient
a) Less than 0.60, unacceptable validity and agreement
b) Equal or greater than 0.60 and less than or equal to 0.70, poor validity and agreement
c) Greater than 0.71 and less than or equal to 0.80, acceptable validity and agreement
d) Greater than 0.80 and less than or equal to 0.90, good validity and agreement
e) Greater than 0.90, excellent validity and agreement

Table 2 Interpretation of the CVC
Source: Hernández-Nieto (2011), p. 100

On the other hand, the experts recommended changes in the following questions, which were applied to obtain the final instrument.

Item	Before	Recommendation
2	Do I know what are the characteristics of celestial bodies, that is, planets, moons, meteors, meteorites found in our solar system?	How well do I know what are the characteristics of celestial bodies, that is, planets, moons, meteors, meteorites found in our solar system?
3	Can I identify the different ways to study and analyze the celestial bodies of our solar system?	How much do I know about the instruments and techniques used to study the celestial bodies in our solar system?
8	Did I know what technology is used to study the celestial bodies of the solar system?	How much do I know about the technological instruments used to study the celestial bodies of our solar system?
17	Did I like using art supplies to color my solar system work?	How much did I like using art supplies to color my solar system work?
25	Did developing this project allow me to think about what I want to do when I grow up?	When developing this project, how much did it allow me to think about what I want to do when I grow up?

Table 3 Recommendations for writing questions
Source: Research data, 2023

Phase 6. Conduct the pilot study

To carry out the pilot test, a small representative sample of 20 students was determined with conditions similar to the sample chosen for the final study (Vara, 2012), that is, 5th grade students on Rural elementary school, 50% men and 50% women; because the sample chosen for the final study was 40 students, 20 men and 20 women.

Phase 7. Carry out the technical study

Once the pilot test of the designed instrument has been applied, the reliability of the instrument is calculated. In this case, being an instrument with polychotomous responses, Cronbach's alpha was applied to measure the internal consistency of the instrument through the RStudio Software version 2023.09.1, obtaining a value of 0.8864, placing it at a Very High reliability level (Ruiz, 2013).

Range	Magnitude
0.81 to 1.00	Very high
0.61 to 0.80	High
0.41 to 0.60	Moderate
0.21 to 0.40	Low
0.01 to 0.20	Very low

Table 4 Interpretation of the reliability coefficient
Source: Ruiz (2013), p. 100

Based on the previous table, the minimum acceptable value for the Cronbach's alpha coefficient is 0.61, however, Celina and Campos-Arias (2005) mention that the minimum acceptable value for the Cronbach's alpha coefficient is 0.70 and the maximum expected value is 0.90, outside of these values the instrument is not considered reliable, on the other hand, alpha values between 0.80 and 0.90 are preferred (Streiner, 2003, cited in Celina and Campos-Arias, 2005).

When performing the correlation analysis of the items (column r.cor) in Table 5, Hernández-Ordoñez and Amador-Licona (2021) mention that if there are values lower than 0.3, the items should be eliminated from the instrument; Therefore, questions P14, P15, P18 and P26 should be eliminated to raise the Cronbach's alpha coefficient; however, the researchers decided to keep them, since there is a completely reliable instrument to be applied in the study.

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	n	raw.r	std.r	r.cor	r.drop	mean	sd
P1	20	0.59	0.56	0.498	0.533	3.6	0.99
P2	20	0.37	0.38	0.349	0.298	3.4	0.88
P3	20	0.67	0.65	0.633	0.609	3.1	1.12
P4	20	0.37	0.38	0.340	0.309	3.7	0.86
P5	20	0.55	0.54	0.505	0.504	3.9	0.79
P6	20	0.60	0.58	0.563	0.540	3.4	1.00
P7	20	0.81	0.79	0.794	0.772	3.7	1.13
P8	20	0.72	0.72	0.728	0.682	3.6	0.93
P9	20	0.77	0.77	0.774	0.739	3.8	0.72
P10	20	0.45	0.46	0.418	0.371	4.1	1.02
P11	20	0.33	0.33	0.314	0.258	4.1	0.97
P12	20	0.68	0.67	0.678	0.624	3.5	1.10
P13	20	0.44	0.42	0.386	0.362	4.2	1.09
P14	20	0.14	0.17	0.094	0.088	4.3	0.66
P15	20	0.24	0.22	0.192	0.177	3.8	0.77
P16	20	0.47	0.46	0.463	0.401	4.0	1.03
P17	20	0.29	0.32	0.304	0.252	4.8	0.41
P18	20	0.22	0.23	0.215	0.148	4.3	0.88
P19	20	0.68	0.69	0.705	0.630	4.1	0.91
P20	20	0.63	0.64	0.607	0.576	4.1	0.91
P21	20	0.76	0.76	0.748	0.730	3.8	0.79
P22	20	0.76	0.76	0.765	0.724	4.4	0.82
P23	20	0.68	0.70	0.704	0.648	3.9	0.72
P24	20	0.37	0.38	0.354	0.309	4.3	0.80
P25	20	0.29	0.32	0.308	0.236	4.4	0.68
P26	20	0.15	0.18	0.139	0.114	4.7	0.47

Figure 2 Item statistics
Source: Research Results, 2023

Conclusions

The design and validation of measurement instruments is not an easy task; it requires an entire process to follow to have a valid and reliable instrument that allows us to obtain data that ensures decision-making in the research carried out.

The questions must be related to the concept of the variable to be measured, to ensure that the instrument is truly measuring said variable. In addition, it must undergo validation, in this case, experts in pedagogical topics were selected to be certain that the questions are correctly designed in their content; On the other hand, a pilot test must be applied to obtain the reliability of the instrument, perform an analysis of the correlation of the items to make decisions to retain or eliminate items that allow us to increase the reliability coefficient of the instrument.

We conclude that, after carrying out the entire process described, there is a reliable measurement instrument to evaluate the implementation of STEAM with a focus on inquiry, which can be applied to learning the solar system in 5th grade students on elementary school.

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Implementation of a greenhouse as a sustainability teaching strategy at university level

Implementación de un invernadero como estrategia de enseñanza de la sustentabilidad a nivel universitario

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Abstract

Considering the sustainable development model, it is necessary for universities to create strategies for teaching sustainability, especially those where Engineering is taught. In this work, a pilot test of a strategy for teaching sustainability integrated into two of the subjects of Biotechnology Engineering is presented. For this strategy, the subject syllabi were analyzed and the construction of a greenhouse with recyclable materials was proposed. The students planned a construction site within the university and proposed a design, considering the established guidelines. Once approved, it was built. The greenhouse was commissioned and currently houses a wide variety of plants belonging to various projects within the university. According to the surveys carried out, the students consider that thanks to the implementation of this strategy they were able to learn something new or reaffirm what they already knew. Therefore, it is necessary that universities develop strategies that help students better understand sustainable development.

Sustainable development, Teaching strategy, University

Resumen

Tomando en cuenta el modelo de desarrollo sostenible es necesario que las universidades creen estrategias para la enseñanza de la sustentabilidad, especialmente aquellas en donde se imparten Ingenierías, en este trabajo se presenta una prueba piloto de una estrategia de enseñanza de la sustentabilidad integrado a los temas de dos de las materias de la Ingeniería en Biotecnología. Para esta estrategia, se analizaron los temarios de las materias y se planteó la construcción de un invernadero con materiales reciclables, los estudiantes platearon un sitio de construcción dentro de la universidad y propusieron un diseño, tomando en cuenta los lineamentos establecidos, una vez aprobado fue construido. El invernadero fue puesto en marcha y actualmente alberga una amplia variedad de plantas pertenecientes a diversos proyectos dentro de la universidad. De acuerdo con las encuestas realizadas los alumnos consideran que gracias a la implementación de esta estrategia pudieron aprender algo nuevo o reafirmar lo que ya sabían. Por lo anterior, es necesario que en las universidades se plateen estrategias que ayuden a los estudiantes a comprender de mejor manera el desarrollo sostenible.

Desarrollo sostenible, Estrategia de enseñanza, Universidad

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1. Introduction

The current state of deterioration of nature is forcing us to change the paradigms on which we have relied to educate new generations. This entails a change in the teaching strategies that are applied in educational institutions, that is, we must migrate to new teaching models based on sustainability.

The UN (2023) defines sustainability as the series of actions that allow humanity to "meet the needs of the present without compromising the ability of future generations to satisfy their own needs," and it is the development model to which they aspire. migrate in the coming years, because of this the need arises to educate new generations under this new way of life.

Education helps us form a collective conscience about the needs of society and therefore is one of the most efficient instruments available for future generations to commit to sustainable development (Cantú-Martínez, 2014).

In this sense, Universities function as spaces whose function is to contribute to finding solutions to new global and local challenges through cooperation between universities or with industry to strengthen sustainable development through professional development by graduates, as well as the training of citizens committed to the three dimensions of sustainable development: economic, social, and environmental (Fernández Pérez, 2018).

That is, the University must commit to sustainable development, for which a review of graduation policies and profiles is necessary, modifying them to meet this objective (Buitrago *et. al.* 2020).

Some of the main problems to solve are:

- Protect nature
- Manage natural resources
- Solve environmental problems
- Analyze the links between economy, ecology, and society

For this, PBL-type teaching strategies are proposed, as well as case studies, if it is not possible to do field practices or stays.

One of the most important characteristics is that these projects must promote self-reflection and, in this case, promote sustainable development (Dieleman and Juárez-Nájera, 2008).

Various authors affirm that the curriculum and research in universities must be rethought since as progress in industries is led by engineers, a direct relationship can be established between sustainability and engineering (Buitrago *et. al.* 2020).

Thus, this work proposes a strategy for teaching sustainability through the implementation of a greenhouse, with students of the Biotechnology Engineering (IBT) degree, from the Polytechnic University of Cuautitlán Izcalli (UPCI), in the state of Mexico.

2. Methodology to be developed

2.1 Polytechnical University of Cuautitlán Izcalli (UPCI)

The UPCI is in the Lomas de Cuautitlán neighborhood in the municipality of Cuautitlán Izcalli, in the State of Mexico. It has bachelor's degrees in business and administration and engineering in Biotechnology, Biomedical and Energy. It belongs to the BIS system, which means that it is an institution that is governed by three characteristics: being Bilingual, International and Sustainable.

It has a type of clay soil that, due to the state of pollution, is difficult to cultivate, the climate is usually dry, and its type of vegetation is xeric scrub.

2.2 Population

The study group consists of 22 students with ages ranging between 21 and 25 years, belonging to Biotechnology Engineering and were studying the subjects of Environmental Biotechnology and Agricultural Biotechnology (Cuautitlán Izcalli, 2023).

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2.3 Methodology

2.3.1 Analysis of the syllabi

The syllabi of the Environmental Biotechnology and Agricultural Biotechnology subjects were analyzed to propose a project that was transversal.

2.3.2 Project proposal

Once the syllabi had been analyzed, the students were proposed the project to follow, which consisted of the implementation of a greenhouse within the UPCI facilities. Monthly reviews of progress were made, which were evaluated through checklists.

Initially, students were asked to make a proposal, through bibliographic research and specialized software (Lab VIEW, for design and COCO Simulator, for calculations).

2.3.3 Construction

Once the proposal was reviewed, the students built the greenhouse prototype with the help of recycled materials.

2.3.4 Application of the survey

Once the greenhouse was built, the students were asked to answer a survey in electronic format, in which they were asked to answer 5 questions regarding their learning. This survey would have the format of a rating scale where the number 1 corresponded to “I did not learn anything new” and 5 to the option “I learned something new or reaffirmed the knowledge I already had.”

3. Results

3.1 Analysis of the syllabi

Once the syllabi were analyzed, it was determined that according to the specific knowledge required in each subject, the most pertinent proposal would be the construction of a greenhouse.

The proposal is that in this site the necessary conditions can be had to maintain the plants that are needed in the subject of Agricultural Biotechnology and the soil be restored according to some of the techniques seen in Environmental Biotechnology

3.2 Study subjects

This pilot test was applied to a group of 22 students, of which 15 were female and 7 were male, all Biotechnology Engineering students in the ninth and eighth semesters of the UPCI.

3.3 Selection of the area for establishing the greenhouse

A site within the university was selected to locate the greenhouse. The characteristic of this site was that it had little traffic and sufficient area available for the establishment of the plantations (Figure 1).

Figure 1 Area for establishing the greenhouse within the UPCI
Own Source, 2023

3.4 Soil restoration

Due to the contamination of the soil, it was proposed to restore it using compost that was made with the waste from the institution's cafeteria. The soil was also leveled, cleaned and all weeds were removed (Figure 2).

Figure 2 Soil restoration of the area selected for the greenhouse
Own Source, 2023

3.5 Greenhouse construction

Once the soil was nourished, the recycled wood posts were placed for the positioning of the shade mesh (Figure 3).

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Figure 3 Placement of the posts for positioning the shade mesh
Own Source, 2023

3.6 Establishment of the greenhouse

Once the greenhouse was established, various types of plants were grown (Figure 4).

Figure 4 View of the greenhouse with some plant species
Own Source, 2023

3.7 Survey results

Once the survey was answered, the following results were obtained: 76% of the students considered that they had acquired or reinforced new knowledge that can help them pursue their career.

4. Conclusions

This work shows a strategy for teaching sustainability for university students, which is of utmost importance since it is the economic development model that will predominate globally in the following years.

According to the results of the survey, this strategy helps students have a better understanding about sustainability, as well as reinforces previously acquired knowledge and facilitates the acquisition of new knowledge.

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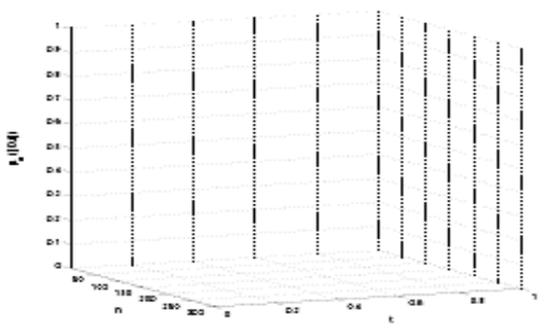

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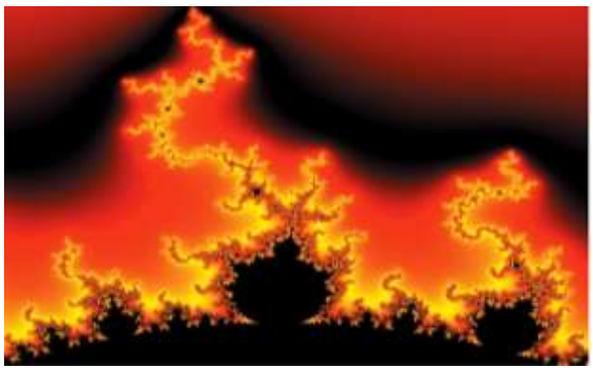

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