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

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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.

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.

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.

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

−   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.

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:

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

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
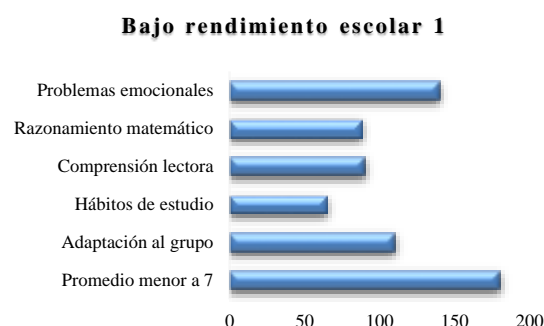
Graph 1 Diagnostic evaluation

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.

Progress in reading comprehension
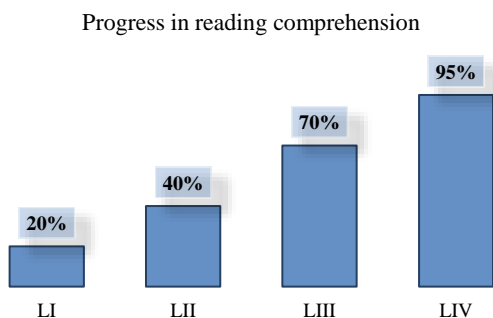
Graph 2 Progress in reading comprehension throughout the semester

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.
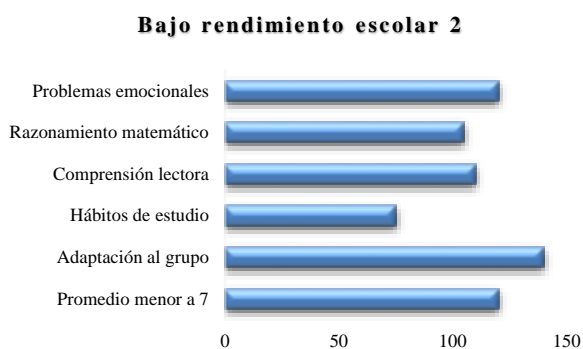
Graph 3 School performance second assessment
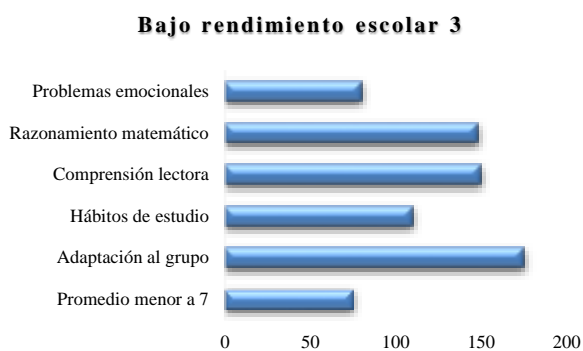
Graph 4 Final evaluation performance

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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