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Research Article

HydroHackathon Sustainable Solutions from Artificial Intelligence

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ABSTRACT

In the midst of a global crisis due to the loss of social, environmental and economic balance, it is urgent to solve this situation with innovative and sustainable proposals that subscribe to the ODS, the HidroHackathon is an academic event where project proposals are developed through the Methodology STEAM-ABP with the Integration of Artificial Intelligence in this event achieves excellent results to create real effective solutions by subscribing with this to the ODS through the application We conclude that the AI application of the K-Means algorithm is fundamental for data analysis for the generation of solutions for Sustainable Development.

Keywords: Artificial Intelligence, Hackathon, Methodology STEAM-ABP, Sustainable Development.

INTRODUCTION

In the midst of a strong water, environmental, social and economic crisis caused by the loss of balance, it would be of utmost importance to place global needs as a priority. Technological advances are a constant, in many cases they require energy which causes demand to increase. energy and sometimes generate pollution, however it is also possible that technology, in addition to facilitating processes, can also be of great help in contributing to the solutions of the problems facing humanity.

To achieve a sustainable world, a balance between the social, environmental and economic spheres is desirable, ensuring that the main global problems are addressed, among which the following stand out: Poverty, Lack of clean water, Overpopulation, Loss of habitat, Alteration of the landscape, Extinction of species, Global warming, Destruction of the ozone layer, Deforestation and Scarcity of natural resources. These global problems are represented in the Sustainable Development Goals (SDGs). The SDGs are a set of 17 objectives that propose systematic responses in order to achieve sustainable development [1]

In order to achieve the necessary changes, it is important to influence the educational field, which is also transformed, which is why some institutions adopt Education 4.0. In the case of the National Polytechnic Institute in Mexico, Education 4.0 is adopted as the guiding axis [2] which allows the training of Talent 4.0, Education 4.0 defines it [3] as the education that aims to train individuals with knowledge, technological skills, STEAM skills as well as their social skills and with values that they apply in favor of common good.

This comprehensive training is developed through active methodologies, in which students are placed at the center of the activities; it is the students who carry out the tasks and develop skills. Among the active and innovative strategies is the Hackathon as an academic event where the STEAM -ABP methodology is applied. Understanding STEAM, which by its acronym in English are S- Science, T- Technology, E- Engineering, A- Arts and M – Mathematics [4], disciplines that together achieve the creation of innovative sustainable solutions providing answers to sustainable development objectives.

Technology allows us to carry out endless activities such as control, analysis, estimates, simulations, design, programs for specific actions among many other applications that without it would not be as accessible as they are on a daily basis. Therefore, the use of technology and especially Artificial Intelligence (AI) serve to generate sustainable innovations which must be the constant in our days, in this way they would achieve great advances towards the solution of the SDGs.

LITERATURE REVIEW

The term Sustainability means "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [5]

The development of the industry, the consumerism of society and the advancement of technology without the correct environmental ecological perspective has caused problems that prevent a sustainable world, in that same sense [6] the lack of social responsibility, the scarcity of key resources for living, the extinction of species, as well as the high incidence of poverty in populations that are in continuous growth, which causes a great global imbalance.

Due to the loss of balance, those interested in the topic began to mention the term sustainability as a term that was associated with the balance of human activities with nature. As mentioned, [7]

It is impossible to conceive of the human being independent of the resources that the environment provides him; Their food, and all the material inputs that support the production of goods and life itself, are supported by the earth's ecosystems, hence the importance of conserving them.

The term Sustainability is ambiguous, they consider it incomplete because it does not contain all the aspects involved, hence some authors propose that the correct term is Sustainable as established in the Brundtland report [5]

To achieve a sustainable world, balance is required between the social, environmental and economic spheres in order to achieve an equitable, viable and livable world as shown in Figure No. 1

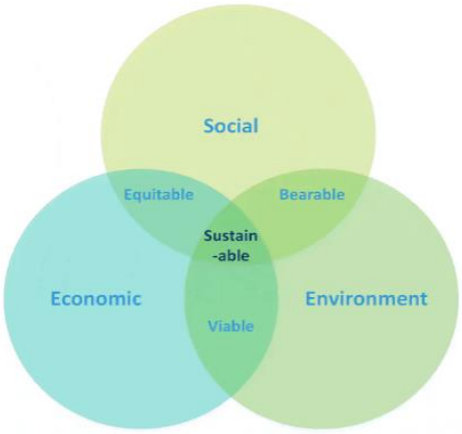

Fig. 1. Elements of Sustainable Development Source: [8] (GiroSalut, 2023)

In order to set clear global objectives, the 2030 Agenda [1] emerged on September 25, 2015, which establishes the Sustainable Development Goals (SDGs). The SDGs are the set of 17 objectives that propose systematic responses with the in order to achieve sustainable development and that address important problems such as inequality, poverty, unsustainable consumption, climate change and to be able to guarantee a better future in all possible areas in the world by anchoring the defense of human rights. Below are the Sustainable Development Goals (SDGs) of the 2030 Agenda. as shown in Figure No. 2

Fig. 2. Sustainable development goals SDG Source: [1]

Education 4.0

Education 4.0 is defined [3] (Fernández, 2020) as education that aims to train individuals with knowledge, technological skills, STEAM skills, as well as their social skills and with values that they apply in favor of the common good.

Education 4.0 as a means to prepare Talent 4.0 that is used in Industry 4.0 (I4.0). Industry 4.0 is defined [9] as that which takes advantage of information technologies, robotics and sensors, which results in the Internet of Things (loTs) and other Technologies. According to Boston Consulting Group[10] they mention the nine pillars of Industry 4.0: Big data, Simulation, Additive Manufacturing, Horizontal and vertical integration systems, Cybersecurity, Augmented Reality, Cloud Computing, Autonomous Robots, Industrial Internet of IIoT things; These technologies and others are recognized according to [11] Of course, Artificial Intelligence has taken a prominent place due to its advances and valuable contributions in various areas.

According to [2] the term Talent 4.0 is given to people who demonstrate outstanding aptitude (in terms of ability and attitude) as well as those who possess or eminent competence in one or more domains associated with Industry 4.0 (especially digital attitude, creativity, innovation and STEM skills.

To train Talent 4.0, active and innovative strategies are carried out such as the Hackathon, which is an academic event where the STEAM -ABP methodology is applied in order to meet the challenge of designing a sustainable innovative solution through collaborative transdisciplinary work.

STEAM

Understanding STEAM as its acronym in English are S- Science, T- Technology, E- Engineering, A- Arts and M-Mathematics [4] disciplines that together achieve the creation of sustainable innovative solutions by providing answers to the sustainable development goals. STEAM was born to motivate students to study science, the acronym STEAM shows the union of these sciences to achieve transdisciplinarity in order to create sustainable innovative solutions from these sciences, it is a fundamental part of STEAM that innovations are contributions to the solution to the SDGs, the talents of young people are also considered to form work teams, promoting collaborative work in a work-like environment.

Developing STEM skills means having skills in science and technology among other skills, as well as the knowledge of the different disciplines required to achieve new solutions [12] Another advantage is that STEAM promotes Soft Skills that will allow the individual to relate appropriately, form teams, self-direct, regulate and manage your knowledge. [13] STEAM promotes the development of critical thinking and develops or strengthens the required work skills: the research process, diagnosis and proposal of solutions, work methodology, definition of objectives, prevention, conflict resolution, team management, coordination of activities.

STEAM has the ability to merge the STEAM disciplines, described in one of five ways: transdisciplinary, interdisciplinary, multidisciplinary, interdisciplinary, and arts integration. [14] In this same sense, according to[15] STEAM also proposes a theoretical framework for teachers to develop a STEAM program aimed at improving the teaching and learning of science in an intercultural context. The application of the STEAM methodology according to

[16] proposes creates an interdisciplinary pedagogical model, which addresses sciences (biology, chemistry and earth sciences), technology (biotechnology, information and green technology), engineering (living technology, disaster prevention technology and electromechanical applications), art (scientific argumentation, scientific drawing, cultural creativity and scientific writing) and mathematics (logical reasoning). For the successful application of STEAM [6] they also suggest that they be associated with Project-Based Learning (PBL) in conjunction with STEAM to structure the development of the project, since which makes it easier for students to work in an orderly manner.

There are various advantages associated with STEAM learning, skills such as autonomy and entrepreneurship, collaboration, communication, knowledge and use of technology, creativity and innovation, product design and manufacturing, critical thinking and problem solving are developed [17] STEAM It allows the development of creativity and motivates students to create solutions to proposed problems. STEAM is an integrative methodology that develops technological and research skills, as well as Socio-emotional Skills as mentioned [18]

Hackathon

The definition of the Hackathon is an academic event where a challenge is raised that must be solved as a team by creating an innovative and sustainable solution. [19] Hackathons are events that are a kind of application or project development marathons, lasting between 24 and 48 hours, which became increasingly popular as a method to learn quickly and lead people to carry out creative projects in a short space of time. According to [18] these events use and generate knowledge, use and develop technological, digital and socio-emotional skills when working in collaborative teams.

[20] It is this same sense when carrying out this type of event among students, they learn and develop various skills and competencies. [21] Hackathons bring together a diverse group of interdisciplinary professionals from different industries who work as a team and learn from each other, focusing on a specific problem

Hackathons began as technological events, however, upon observing the advantages and benefits, they have been developed in other disciplines as mentioned [22]. The most frequent thematic areas were computing, social sciences, engineering, medicine and business.; As in the case of this investigation, the Hdrohackathon is carried out with the objective of finding solutions for the Santiago River in the city of Guadalajara Jalisco located in the western part of Mexico.

In Hackathons, the challenges posed are contextualized situations that represent challenges that are not isolated situations, for example, social and environmental problems are generally related to the community and economic situations; Therefore, integrative solutions are required where social, environmental and ecological areas are addressed, preferably contributing to the SDGs.

Sometimes it is organized, constituting an average of six groups of eight people: five students from different universities and different university courses and three professionals from different sectors to transmit their experience. Throughout the day, each group must solve an entrepreneurship case with a social objective. The theme of the project to be developed is given to all groups at the same time at the beginning of the work day. [23] In other cases the challenges are to find the solution or contribution to the SDGs.

Hackathons generate knowledge, develop skills in a short time and generate surprising proposals. However, there are disadvantages according to [24] Due to a lack of continuity, projects end up dying and therefore the thread of innovation is lost. It is also worth it It should be noted that the participants are very motivated and have high self-esteem when they see their achievements and recognize their abilities, knowledge and skills developed during the event.

The Hackathon was created in order to offer new learning experiences to students of diversified education. In the process, creativity and innovation in problem solving is encouraged through the theoretical-practical and social interaction of students. implementation of technology that involves observation, design, prototype development, experimentation, analysis and scientific dissemination. [25]

Artificial Intelligence AI

In 1956, the term “artificial intelligence” began, coined at a conference at Dartmouth University organized by John McCarthy. It continued to evolve in 1986. Learning to learn with back propagation, progress continued until 2010,

which would do two things. possible the revolution of applications of neural networks and deep learning algorithms. [26]

Currently Artificial Intelligence (AI) refers to the ability of a machine to perform tasks that normally require human intelligence, such as learning, problem solving, perception, language understanding and the ability to make decisions. AI achieves analyzes that surpass human capabilities, making it a powerful tool in conjunction with the interpretation of human experts.

Adding to the achievements of AI, a social and environmental commitment has been included, which is why Sustainable AI is developed, which according to [27] is presented as a crucial means to achieve long-term environmental and social sustainability goals., promoting responsible practices that allow us to harness its transformative power to effectively address global challenges.

Below are some examples of the application of AI in sustainable projects. In most companies in diverse and numerous fields, AI can be applied to increase the sustainability of organizations, as an example of Data Science in organizations that have managed to maintain the sustainability of their processes and thereby contribute to the SDGs worldwide.

In the school environment, AI, according to [28], can offer significant opportunities to improve education, both for teachers and students, highlighting its potential to transform educational environments. In this same sense, AI is also a powerful tool for searching for information, as well as for data analysis.

In service companies, AI can provide transcendent information about the client to be able to satisfy their requirements, project and estimate their needs, as mentioned [29] you can know the consumer experience in tourism and their preferences, through collaboration between different organizations that seek to promote social innovation and contribute to the sustainable development of the sector. The data collected is analyzed in AI, which provides the opportunity to know the estimates and projections for the sector considering the various actors involved.

Information management is a delicate and high-impact issue, which is why regulations must be integrated, as mentioned by [27] the importance of integrating ethical, social and environmental considerations in the development of AI, highlighting the need to interdisciplinary approaches that balance technological advancement with ethical and environmental responsibility.

AI can be used to manage resources, such as water, create smart cities, improve traffic management, study the accumulation of waste and monitor the exploitation of the territory. Climate change and human activities are aggravating natural phenomena such as global warming, and AI is presented as a key tool to address these problems and advance towards sustainable development goals. The analysis explores how AI can contribute to sustainability and the prevention of natural disasters [30], resolution of environmental problems and also as mentioned [31] Traffic management, sustainable agriculture with AI and management of natural resources.

AI also contributes to the generation of awareness in social situations by quickly accessing information. AI provides research and teaching experiences, analyzes the growing use of artificial intelligence, as well as an applied perspective aimed at developing skills in data collection and processing, automated content creation and content verification. [32] It is worth mentioning that AI is not included in all postgraduate courses and will be a necessary skill for decision-making.

The Integration of Artificial Intelligence in Education for Sustainable Development ESD offers great opportunities and challenges as mentioned [33] AI will be able to evaluate the opportunities and challenges associated with ESD, as well as the personalization of learning, efficiency in educational management and content development.

AI presents the possibility of having good data to achieve efficient results in decision-making, which is very favorable for actions that allow progress towards sustainable development.

METHODS AND METHODOLOGY

The STEAM-ABP Methodology was applied in the HidroHackathon, which is ideal for the research process and creation of innovative sustainable solutions. The STEAM-PBL methodology allows you to take advantage of the benefits of the STEAM transdiscipline through the development of a research process mediated by the stages of Project-Based Learning (PBL); Both methodologies provide valuable elements for a work structured in stages and with the possibility of rectifying any of them as many times as necessary.

For the successful application of STEAM [6]) they also suggest that they be associated with Project-Based Learning (PBL) in conjunction with STEAM in order to structure the development of the project, since which makes it easier for students to work in an orderly manner. As shown below in Fig. No. 3

Fig. 3. STEAM-ABP Methodology Source: [6]

According to [6] (Yarzábal, Ávila, Martínez, Álvarez, & Núñez, 2022), conducting a Hackathon applying the STEAM-ABP methodology helps students create a structured sustainable innovative proposal and at the same time with the advantage of developing technological and procedural skills. and social-emotional skills. In that same sense [21] mentions that the application of new tools to encourage student learning has been implemented within the educational challenge of Hackathons, such as the opportunity to practice intensively. project-based learning (PBL).

It is part of the STEAM Methodology that innovations are rigorous contributions to the solution of the SDGs as well as the talents of young people are also considered to form collaborative work teams.

After the formation of teams, the data was reviewed and analyzed and this was what happened after observing the database with 25 measurement points along the river and with an age of more than 10 years and with 75 measurement parameters, it was decided that a proposal would be to use Artificial Intelligence (AI) to analyze the data from the vast database.

After a prior analysis of the data as well as cleaning, it is decided to use a machine learning algorithm. Application of K-Means is a subset of Artificial Intelligence AI. The K-Means application's function is to group data into groups (clusters) based on similarities. Which helps to find patterns and understand how the different sampling points behave depending on the parameters of the Santiago River located in Guadalajara.

The goal of K-Means is to minimize the sum of the squared distances between data points and the centroid of their assigned cluster. The algorithm works using an iterative approach to adjust cluster centroids and minimize the total error function. Formally, the goal is to minimize the following function:

$$J = \sum_{i=1}^{k} \sum_{x_i \epsilon C_1} \|x_j - \mu_i\|^2$$

Where:

- J is the cost (or inertia) function,
- K is the number of clusters,
- Ci represents the set of data points assigned to cluster i,
- μi is the centroid of cluster i,
- xj is a data point.

The K-Means algorithm follows a series of iterative steps until the clusters stabilize or a maximum number of iterations is reached. The main steps are:

1. Initialization:

   o A K number of clusters is chosen.

   o K random points are selected as the initial centroids of the clusters.

2. Cluster Assignment:

Each data point is assigned to the cluster whose centroid is closest, using the Euclidean distance as a proximity criterion. The Euclidean distance between two points x and y in n-dimensional space is given by:

$$d(x,y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

3. Centroid Update:

Once all points are assigned to their respective clusters, the centroids are recalculated. The new centroid of each cluster is the arithmetic mean of all observations within the cluster:

$$\mu_i = \frac{1}{|C_i|} \sum_{x_j \epsilon C_i} x_j$$

4. Iteration:

Steps 2 and 3 are repeated until the point assignments no longer change (convergence) or a maximum number of iterations is reached. Convergence occurs when the cost function no longer decreases significantly from one iteration to the next.

Selection of the Number of K Clusters

A critical aspect of the algorithm is the choice of the number of clusters K. There is no exact mathematical method to determine K, but there are several empirical methods, such as:

- Elbow Method: It consists of running the algorithm for different values of K and calculating the sum of the squared distances within the clusters (inertia). The optimal value of K is chosen where the decrease in inertia begins to decrease abruptly, forming an "elbow" in the graph.
- Silhouette Score: Evaluates the quality of clusters based on how close points within the same cluster are compared to points in other clusters.

DEVELOPMENT

Hydrohackathon began with the manifestation of the challenge to be solved, which consisted of generating innovative sustainable proposals to improve the critical environmental situation in which the Santiago River is located near Guadalajara, Mexico, which is the capital of the state of Jalisco. This river is the largest tributary that supplies water to that state and also contributes to supplying the water that is supplied to Mexico City.

Each team was integrated with the participants according to their talent, trying to be balanced in order to generate innovative proposals. There was one student per team with knowledge of sustainability, programming, design and engineering.

The teams followed the steps of the STEAM-ABP methodology that helps them understand the stages of project development.

A team decided to use Artificial Intelligence to work with the application of AI through the K-Means algorithm. Once the method for data analysis through the K-Means application was defined, the following steps were carried out:

- The Preparation of data on the Puente Grande River parameters at different sampling points and dates. The parameters include parameters such as Conductivity, Turbidity, Dissolved Oxygen, among others as mentioned.
- Data Normalization, this is done because different parameters have values on very different scales (for example, conductivity can be a very high number, and pH is a small number). If we do not normalize, parameters with large numbers (such as conductivity) would influence clustering more, which is not ideal.

Application of K-Means

- The K-Means algorithm divides the data into K groups (clusters) in such a way that points in the same group are as similar as possible, while points in different groups are as different as possible.
- o 3 clusters were used as a starting point.
- o Random assignment of sampling points to these clusters.
- o Calculation of the centroid of each cluster (the average of all points in the cluster).
- o Reassignment of the sampling points to the closest cluster according to the new centroid.
- o It is repeated until the clusters no longer change.

RESULTS

The proposals emanating from the Hydrohackathon were presented to the organizers, the teams had to argue and explain why their proposal was sustainable and mention which SDGs they contributed to. The teams focused on contributing to the solution of cleaning up the Santiago River. Among the proposals presented were an educational campaign, the design of a biomass plant due to the high rate of waste from livestock farms, as well as the design of the procedure to trap fat in the river. The team that proposed the AI Application through the K-Means algorithm obtained the following graph that represents the data from the database after analysis

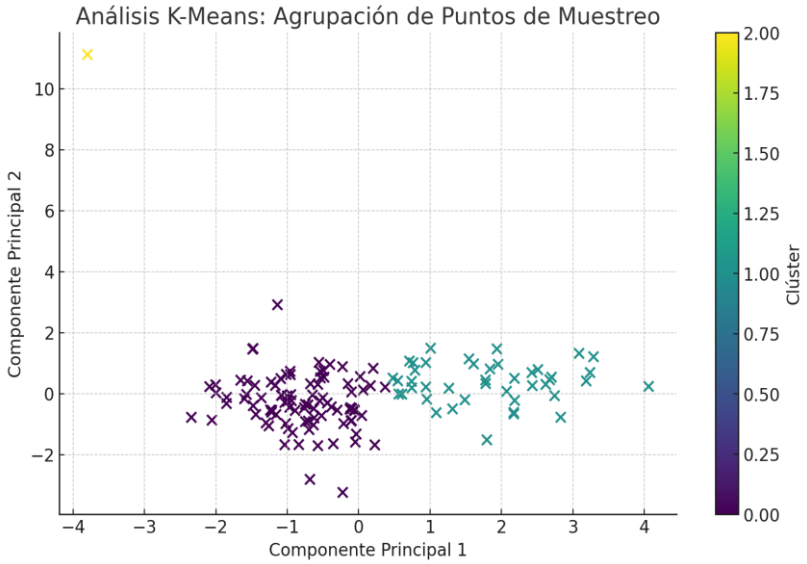

Fig. 4. Analysis of Grouping of Sampling Points by AI Application Source: Own Production

Each point represents a sampling point, and the colors show which cluster each one belongs to. The sampling points were grouped into 3 clusters. Points with the same color are in the same group, which means that they have similar characteristics in the water quality parameters in the Puente Grande River.

Based on the average values of each parameter for each cluster. The characteristics of each cluster are interpreted:

Cluster 0:

There are moderate levels of conductivity (991), turbidity (29.78), and a relatively high temperature (22.61).

Dissolved oxygen values are also moderate (2.24).

This cluster could represent sampling points with acceptable or typical water quality.

Cluster 1:

This group has the highest values of total acidity (2.93), conductivity (1315), and turbidity (16.57), with a slightly lower temperature (20.20).

These sampling points could be in more contaminated areas or with lower water quality, given that high acidity and turbidity are usually associated with contamination problems.

Cluster 2:

All values are close to 0, indicating that this group could represent points where no data were recorded or where values are extremely low.

These results are undoubtedly a very good start since they locate which measurement points have the highest data in terms of the selected parameters, so proposals can be started on how to solve the measurement points with the most critical data that belong to the Cluster. 1. The ease that this information provides is that the most critical of the critical measurement points are also known, which allows for a thorough analysis of where it is located that originates the data so high what type of activity is carried out in the area, whether industrial, livestock or mining to try to propose actions to reverse these critical measurements. The benefit of the analysis through the Application of AI through the K-Means algorithm is the possibility of knowing where to start the arduous management with those involved to achieve progress in the sanitation of the Santiago River, contributing to SDG 6 Clean Water.

CONCLUSION

The hackathon, which on this occasion was called HydroHackathon for its challenge of cleaning up the Santiago River, in Guadalajara, Mexico, fulfilled the purpose of designing innovative sustainable proposals in order to contribute to SDG 6 of Clean Water.

AI in Education for Sustainable Development EDS is a success if it is used in academic events called Hackathon where innovative proposals for the SDGs are sought to be generated, which can be done more easily after data analysis through AI.

AI provides valuable and reliable information to indicate critical situations. It is shown that analysis through the Application of AI through the K-Means algorithm is a very good option to obtain relevant information to begin solving the problem by knowing the most critical measurement point of the 25 existing measurement points throughout of ten years. We conclude that the application of AI is fundamental for data analysis to generate solutions for Sustainable Development.

DISCUSSION

The holding of academic events Hackathons are an excellent opportunity for learning and skill development, as well as for the generation of sustainable innovative solutions so that there are more events and training opportunities, more teachers with STEAM and PBL training are required in addition to professional training end to the challenges as well as the willingness to participate as a mentor or organizer in the Hackathon. The profile of the teachers involved is essential to motivate and accompany students in this intense and enriching learning experience.

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Data Availability

Declare the availability of the data used in the manuscript

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