Revista de Divulgación Científica HUMMATEC
REVISTA CIENTÍFICA MULTIDISCIPLINARIA NEYART

# THE GAME THAT CHALLENGES YOUR MIND AND SHARPENS YOUR WIT, BASED ON LOGIC AND PROGRAMMING

THE GAME THAT CHALLENGES YOUR MIND AND SHARPENS YOUR WIT, BASED ON LOGIC AND PROGRAMMING

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**DOI:** https://doi.org/10.61273/neyart.v4i1.167 | **Received:** 12/06/2025 | **Accepted:** 02/10/2026 | **Published:** 03/14/2026

***Summary--*** The project is an automated memory game for children ages 6 and up. It aims to be a playful educational tool. It teaches dinosaur names in a technological and accessible way, in line with SDG 4: Quality Education. The system uses a rack-and-pinion mechanism to automatically move the cards, incorporating mechatronics and Boolean control logic. It improves memory, attention, and problem-solving skills from an educational perspective. It reinforces values such as honesty, provides tools for managing frustration, and strengthens communication between parents and children. This project is a versatile application for child development that transforms spaces into inclusive and engaging learning environments.

***Keywords--*** Learning, Early childhood education, Educational game, Teaching materials, Educational technology.

***Abstract--*** This project is an automated memory game for children ages 6 and up. It aims to be a fun and educational tool that teaches dinosaur names in a tech-friendly and accessible way, in line with SDG 4: Quality Education. The system uses a rack-and-pinion mechanism to automatically move the cards, incorporating mechatronics and Boolean logic. It improves memory, attention, and problem-solving skills from a pedagogical perspective. It reinforces values such as honesty, provides tools for managing frustration, and strengthens communication between parents and children. The project is a versatile application for child development that transforms spaces into inclusive and engaging learning environments.

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## INTRODUCTION

This interactive project is an educational mechatronic application that combines precision engineering and digital control logic to create an interactive memory game. The system uses Boolean logic and ladder diagram programming, operating with Arduino Nano boards and Outseal PLC software.

The prototype features a rack-and-pinion drive system that uses servo motors and planetary gearboxes to ensure an optimal user experience. This capability allows rotational motion to be converted into a constant linear motion for opening and closing the panel's hatches.

The combination of these elements, along with a structure designed in SolidWorks and manufactured from sustainable materials such as recycled MDF and PLA, creates a robust device capable of providing immediate tactile feedback to the user, confirming correct or incorrect responses through automated processes.

The problem encountered in early childhood education is that there is a disconnect between conventional analog teaching materials and 100% digital tools. This lack of physical technological resources hinders the development of logical-mathematical thinking and kinesthetic memory in children aged 4 to 6. Therefore, the overall objective is to design and build an automated mechatronic prototype that integrates Boolean logic and control systems to strengthen cognitive skills through playful learning.

## JUSTIFICATION

The project arises from the pedagogical need to develop strategies that engage children and move beyond the conventional, repetitive, and rote-learning models on which their education is based—models that lack interactive components. This initiative responds to the lack of accessible tools that integrate technology, pedagogy, and emotion, a gap that limits the development of inclusive, high-quality educational processes.

The project aligns directly with SDG 4 (Quality Education), Target 4.2, to ensure that all children have access to quality early childhood development. Through a mechatronic system based on Boolean logic and ladder diagrams, it is possible to teach about dinosaurs in a fun way and improve cognitive skills such as memory and problem-solving.

Furthermore, the proposal is socially and economically viable, as it uses recycled materials (MDF from university workshops) and open-source technology (Arduino and Outseal), enabling the development of a replicable and sustainable resource for venues such as the Museo del Rehilete.

## DEVELOPMENT

The creation of the project combines mechatronics engineering with current pedagogical theories to develop a functional and educational system. The design, construction, and programming stages of the prototype are detailed below.

### Theory of Experiential Learning

From an educational perspective, David Kolb's theory of experiential learning is adopted, which establishes a four-stage cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation. In "Jurassic Match," this cycle translates into a dynamic where the

The child looks at the card, thinks about its location, generalizes the matching pattern, and applies that information to new moves [3].

### 3.2. Gamification and Prosocial Behavior

The project incorporates gamification elements such as scoring, immediate feedback, and positive reinforcement, which foster intrinsic motivation and persistence. At the same time, prosocial behavior is encouraged by creating situations of cooperation, honesty, and frustration management through interaction with peers or adults [3, 4].

### Mechanical and Structural Design

For the physical structure and movement of the components, computer-aided design (CAD) and digital manufacturing techniques were used:

- **Structure:** The box and board were designed in SolidWorks, taking into account ergonomic measurements for children, and manufactured from 3 mm recycled MDF from the university's manufacturing workshop, cut using laser technology.
- **Actuation mechanism:** A rack-and-pinion system mounted on planetary gearboxes was implemented. This mechanism was selected for its ability to transform the rotational movement of the motors into precise and smooth linear motion, ideal for moving the flaps that conceal the cards.
- **3D elements:** PLA filament was used for 3D printing "dino flexi" figures, adding an aesthetic and tactile component to the prototype.

### Electronic and Control System

The core of the prototype's logical and electrical operation consists of the following elements:

- **Control Hardware:** Three interconnected Arduino Nano boards were used to manage the system's inputs and outputs.
- **Actuators:** The movement of the 16 gates is controlled by **16 servomotors**, managed via a servo expander to optimize wiring and signal transmission.
- **Connectivity:** Approximately 70 meters of 22-gauge wire were used for internal connections.
- **Circuit design:** A custom PCB (Printed Circuit Board) was designed and built using KiCad EDA software. Manufacturing was carried out using vinyl cutting techniques to create the conductive traces.

### Programming Logic and Software

Game control is based on Boolean logic (using binary variables 0 and 1 and AND, OR, and NOT operators) to determine game states.

- **Programming environment:** Outseal PLC software was used, a free tool that allows for programming Arduino microcontrollers using ladder logic.
- **Ladder diagrams:** This language, common in industrial automation, manages the operational sequence using logical "rungs." Timers and relays were programmed to control the game states.
  - *Logic example:* Line 38 of the code activates the timers, and line 39 is used for function interlocking.

For system programming, control logic based on Boolean algebra was used to validate correct answers. The activation state of the reward mechanism (S) is defined by the function:

$$S = (I_A \cdot I_B \cdot K_1) + (I_C \cdot I_D \cdot K_2) + ... + (I_n \cdot I_m \cdot K_x)$$

Where I represents the pushbutton inputs and $K$ is the matching constant assigned in the controller. This logic ensures that only the correct combination of inputs activates the system output. **Operational Functioning of the Prototype**

The programmed game sequence is as follows:

1. **Start:** When the game is activated, the system automatically opens the doors, displaying the cards (illustration and dinosaur name) for **5 seconds**.
2. **Memorization:** The doors close, and there is a **7-second** interval during which the player must retain the information.
3. **Selection:** The user selects two options using physical buttons.
4. **Validation:**
   - **Correct:** If the Boolean logic detects a correct match (valid pair), the doors for those cards remain open as a sign of success.
   - **Error:** If the combination is invalid, the doors close again, encouraging the user to try again.

**3.7. Integration of cognitive levels (Bloom's taxonomy).**

To ensure that the experience goes beyond mere repetition and is truly meaningful, the project incorporates strategies targeting different levels of Bloom's taxonomy:

Recall — recognizing and naming dinosaurs;

Understand — simple questions about distinctive features;

Apply — simple comparison and classification tasks; Analyze

— identifying similarities and differences between species;

Evaluate — justifying choices in game variations with sound

reasoning; Create — creative activities (short stories, drawings).

These stages are operationalized through cards with informational clues, challenge cards with open-ended questions, and adjustable game modes (e.g., "clue mode," "challenge mode") that foster guided dialogue between child and adult, promoting meaning-making in family and school contexts.

## 4. DISCUSSION AND ANALYSIS OF RESULTS

The project advocates integrating mechatronic systems into educational tools for children. As a prototype, the system was accurate, using Boolean logic and ladder diagrams (Outseal PLC) to control the verification of correct answers. The rack-and-pinion system has been the best way to ensure smooth, linear movement of the card covers and, consequently, an ideal user experience. Pedagogically, the method supports Kolb's Experiential Learning Theory, as immediate feedback reinforces the trial-and-error cycle, improving memory, attention, and prosocial behavior in children (they learn to tolerate frustration). Additionally, the project is sustainable and low-cost, using recycled MDF and open-source technology (Arduino). This methodology contributes to SDG 4 (Quality Education) by providing high-quality educational materials.

Performance metrics were achieved in user validation tests (with 6-year-old children). The average time to solve the task on the first attempt was 4.2 minutes, which decreased to 2.8 minutes after three repetitions, representing a 33% improvement in visual processing speed. Additionally, the system had a 15% error rate in identifying complex pairs, demonstrating the effectiveness of the low-cost, replicable light and mechanical feedback system.

## 5. ANALYSIS OF RESULTS

The automated memory game prototype was designed as an educational tool to strengthen cognitive and social-emotional skills in children as young as four. It uses a mechatronic system based on Boolean logic to create an interactive experience. This experience combines observation, visual memory, and decision-making to teach children about the names and characteristics of dinosaurs. The device provides immediate feedback: the flaps remain open when a correct answer is given and close when an error is made, encouraging learning through trial and error. A time limit adds challenge and promotes emotional self-regulation. Physical interaction with buttons and components develops fine motor skills and logical thinking. To ensure accessibility in resource-limited contexts, the design incorporates criteria of modularity and simplification. Low-cost versions are proposed, such as a manual-mechanical version without electricity, a simplified electronic version with a single microcontroller, and the use of local or recycled materials. Open-source plans and teacher guides are included to facilitate community replication. In this way, the project aligns with Sustainable Development Goal 4 by offering an innovative, inclusive, and replicable educational tool for early childhood.

When compared to similar studies, it aligns with the findings of Acuña and Quiñones (2021), who demonstrate that playful strategies enhance logical thinking by 65% in early childhood education. Unlike the software proposed by Medina Carbó (2020), which is designed exclusively for mobile interfaces, this prototype includes a physical mechatronic component to support hand-eye coordination. Finally, the project aligns with Ruiz Ledesma's (2024) definition of gamification as a strategy that extends beyond the traditional classroom by utilizing programmable hardware.

## CONCLUSIONS

The project involved the development of a functional prototype of an automated dinosaur-themed memory game, designed to enhance playful learning in children ages four and up. Its design incorporates mechatronic components—Boolean logic, a rack-and-pinion system, and ladder diagram programming—controlled by platforms such as Arduino and Outseal. The use of recycled materials and an optimized design in SolidWorks make it a replicable, ergonomic, and sustainable resource. From a pedagogical standpoint, it is based on the theory of experiential learning and the use of games, fostering the development of cognitive skills (such as visual memory and concentration), social skills (such as cooperation and empathy), and emotional skills through immediate feedback.

## FUTURE WORK

For future improvements, we plan to expand the informational content on dinosaurs, implement an adjustable difficulty system, incorporate auditory feedback, explore new sensors, and add online connectivity to update content. Likewise, it is considered essential to conduct field tests with real users to evaluate its educational impact. These actions aim to establish the project as an innovative tool aligned with Sustainable Development Goal 4, which promotes access to quality early childhood education. Another proposed improvement is to make it a modular system. This would allow for easy replacement of the cards with other themes such as numbers, planets or animals. This would broaden the range of possibilities. Similarly, the inclusion of a speaker would allow users to receive not only visual but also auditory feedback. As future lines of research, the following are proposed:

1) Incorporating biometric sensors to measure a child's stress or frustration while playing,
2) Developing an IoT interface where teachers can monitor each student's cognitive progress in real time through a cloud-based database.

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## 9. Figures

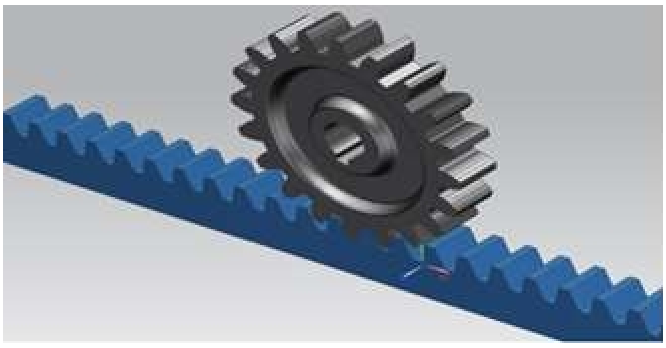

**Figure 1. CAD design and pinion-rack assembly.**

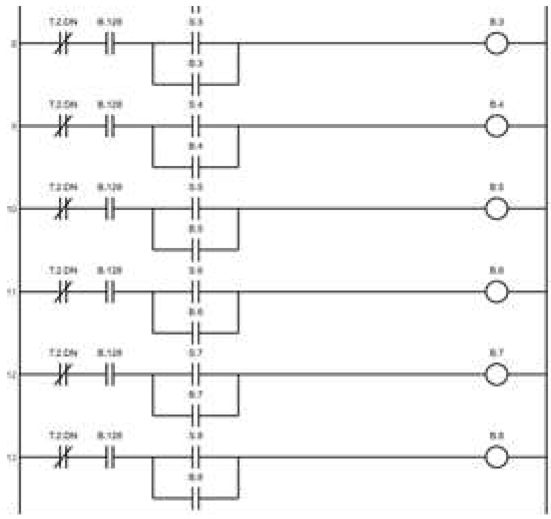

**Figure 2. Ladder diagram section for generating states and Boolean functions.**

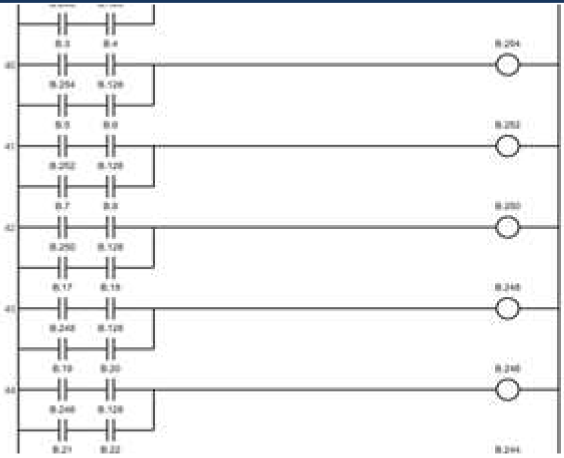

Figure 3. Ladder diagram section for generating memory and interlock functions.


Figure 4. Front panel of the interactive game.

## Acknowledgments

The authors would like to thank La Salle University Pachuca for providing the space and resources in the manufacturing workshop for the development of this project. We would also like to thank our peers in Group 01 of the seventh semester of the Mechatronics Engineering program at La Salle University Pachuca for their support in the development of this project.

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