What do we do when we do The Hour of Code?

Proyecto apoyado por

With the collaboration of:

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This report is part of 2016 Hour of Code Project, developed by the Kodea Foundation and Ucorp together with the Deputy Secretary of Economy and Small Sized Companies from Chile. We have prepared this report with the collaboration of the Center for Research on Social Complexity of the UDD.

Santiago, December 2016.

Introduction

The Hour of Code has expanded rapidly and successfully around the world. According to the creators, Code.org, 98% of the people who have participated in the Hour of Code declare to have had a good experience; 85% of those who begin to study computing, claim that the HoC encouraged them to teach programming. Half of the teachers who took the initiative to their establishments, indicated that they will continue to teach computer science for more than one hour. The global campaign has succeeded in encouraging 1 in 5 teachers to begin teaching computer science.

Programming in a computer language is not easy. Like any other intellectual ability (calculation, statistical analysis, reading comprehension, translation, etc.), it presents important challenges and effort. By introducing programming through a series of short games, the HoC initiative has been able to introduce and effectively involve hundreds of children, young people, and adults, in this fascinating field.

In Chile, we joined the HoC massively, and there are more and more interested teachers and students, being Chile, on its 2016 version, one of the countries with the highest participation worldwide. To a great extent, the important expansion of the initiative is due to the fact that the teachers identified educational value in the activity, which raised two recurring questions in the workshops we have developed: 1) In what way does this help to develop higher cognitive skills? 2) What can we expect from the performance of our students?

These were reformulated into a single question: What do we do when we do HoC? Here we present a first approximation on the joint work together with teachers from Chile, aiming at positioning the use of programming languages as a fundamental pedagogical tool in the classroom, now that we are entering a knowledge economy.

The text will be structured in two parts: the first will present an introduction to the theoretical framework, linking the teaching of programming to cognitive skills, and how these are expressed in the HoC. In the second part, the case of HoC in 4 educational establishments in Panquehue district - Chile, will be shown which served as a case study in the implementation.

What do we do when we do The Hour of Code?

1) Introduction to a cognitive perspective.

The relationship between programming and cognition has received attention from several fields. One of the first steps in this direction is found in Programming Psychology (PP), which:

"It is an interdisciplinary area that covers research in the cognition of programmers; tools and methods for programming related activities; and computer education. The origins of the PP date back to the late 1970s and early 1980s when researchers realized that programming tools and technologies should not be evaluated based only on their computational power but also on their usability from the human point of view, that is, based on their cognitive effects "(Sajaniemi, 2008, p.4).[1]

This turn-from-the-user-side, is due to the various characteristics and mental abilities applied in the process of programming. For example: planning, reasoning, problem solving, the ability to generate and formalize abstractions, among others; factors that, at the same time, are the main obstacles of its learning (Insuasti, 2016). In this scenario, a line of research proposed the idea of programming as an instrument of cognitive development (Pea & Kurland, 1984, Liao & Bright, 1991, Jonassen & Reeves, 1996, Román, et al., 2016, among others), finding favorable results, which have encouraged further research in these areas. (Ahmed, 1992, Guzdial, 2004); (Scherer, 2016).

In this way, in the late 1990s, the thesis of programming and its positive impact on cognitive development was a consolidated topic (Fábrega, et al., 2016). As a result, entering the 21st century, a theoretical line, originally proposed by Pappert 50 years ago, will embrace this relationship in a more holistic way, something known today as "Computational Thinking" defined by Wing (2008) as:

"Programming is not only a fundamental skill in computer science and a key tool to support the cognitive tasks involved in computational thinking, but also a demonstration of computational competencies as well. Programming allows the application of both computational thinking skills, explicit and implicit, incorporating challenges that require high-order thinking (...) The distinctive skills of computational thinking are not about how to program a computer, but rather a cognitive approach to solve problems using abstraction, decomposition, algorithms, and iterative processes "(cited by Sung, et al., 2016, pp. 382-383).

The conceptualization around Computational Thinking has opened new questions on how to understand the connection between programming and cognition and its approach from the educational point of view (Lu & Fletcher, 2009). In order to identify the key competences required by computational thinking, Ambrosio et al., through a study carried out with computer and computer students from the University of Minho in Portugal, conclude that:

"Students' computational skills at the level of academic learning seem to require more of their logical-deductive reasoning skills (inferring and applying or generalizing relationships) and a holistic or simultaneous organization of information (spatial organization). The simple attention or calculation tasks do not seem to be relevant in differentiating students' performance in computer science "(Ambrosio, et al., 2014, p.31).

1 For more information visit the page of the group of interest for programming psychology: http://ppig.org/

On the other hand; Park, Song and Kim (2015), in a controlled experiment analyzing an electroencephalogram of the frontal lobe, demonstrated that the computational thinking has a positive effect in reducing the cognitive load in the students, this is the excess of cognitive resources required to perform a task. According to the researchers, this would happen because

"Education in [Computational Thinking] can help students focus on problem solving in a more strategic way ... by learning problem-solving strategies repeatedly, when students encounter complex problem situations, the cognitive system can homologue solutions[2] *"(Park, et al., 2015, p.42).*

From its early stages, computing has been deep-rooted in human cognition, and even more so in the so-called "Cognitive Era", where some computational devices would be able to homologate certain capacities of the human, to understand the environment that surrounds them and even to make some routine decisions in an autonomous way (Kelly, 2015). This has motivated the search for a greater understanding of human cognition itself: learning as we learn or thinking as we think, that is why cognitive skills are a constituent element of Computer Programming and Science, and today it is urgent to be considered from the pedagogical point of view and that this is not possible without the help of teachers. And we divide it so as to offer the teacher a guide.

2) Mediation and cognitive abilities map.

So far, we have seen an introduction of the relationship between programming and cognition. It is clear that the didactics that incorporates programming, offers a space for the development of cognitive abilities in people, teachers as mediators will be a fundamental part of their development and implementation (Ferreiro & Vizoso, 2008). In this regard, Salomon and Perkins conclude that the model of transferring cognitive abilities offered by programming, occurs "when the path is 'forced' by an instruction that directly and vigorously helps the students to think about programming at an abstract level, in terms of the generic strategies involved "(Salomon & Perkins, 1987, p. 163. Fessakis and colleagues who, beside of validating the use of children-oriented programming resources for the development of cognitive skills, such as problem solving, reinforce the role of the teacher or guide in the involvement of the activities (Fessakis, et al., 2013)

So for the Hour of Code, from the perspective of the results, the important thing is to know if the challenge was solved or not; how many lines of programming were made, among others things, from the point of view of the educational process, the HoC is interested as a pedagogical resource, both to identify the possibilities of change in the learning of its participants, and to provide feedback to the mediator or teacher of how to understand and manage what underlies a task and its cognitive map, that is: to analyze each of the challenges from its modality, content, mental operations, cognitive functions, level of abstraction, level of complexity, among others, so that the teacher is able to recognize the levels of change that their students can experience in learning and the necessities that they can present. On the other hand, mediation in this game is an opportunity for participants to generate resilience through reiterative trial-error, where experience of error can further lead to meta-cognition exercises i.e. How am I thinking? What am I doing wrong? How did I discover the solution?

There are different games in *www.horadelcodigo.cl.* For this work, we studied the HoC Angry Bird[3] (HoC-AB). It is a game that teaches the basics of Computer Science through a visual programming language. This consists of 20 tasks, graduated in increasing complexity in relation to the number of operations that progressively deploys, and that must be controlled, making of the game itself a mental challenge.

We reviewed each of the 20 challenges of the Angry Birds tutorial and divided it so as to offer the teacher, a guide of the processes involved.

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2 Own translation

3 Angry Birds is a series of videogames for computers and mobiles launched in 2009. For more information see: Https://en.wikipedia.org/wiki/Angry_Birds.

Level of abstraction

The HoC-AB game operates at a low to medium abstraction level, since the required mental transformations and operations are based on different representations on an animated pictorial platform, which requires numerical, verbal, figurative and symbolic processing. Finally, the mental process is verified through the concrete execution of the routes according to the orders introduced by the students.

Level of Complexity

Complexity is understood as the amount of information units that are needed to operate and the degree of novelty that can be presented to the student when they are solving the challenges. We could define it from a low to a very high level.

The aspects of abstraction and complexity directly affect the changes and flexibility that students can reach in the cognitive level on the development of these activities. It is for this reason that mediation should be essentially oriented so that those who learn, record the data in an orderly and systematic manner, and categorize them to achieve greater control. This is because they must simultaneously use different modalities, coordinate instructions, and project them topologically in the space of the labyrinth.

Modality

The modality specifies the language in which the tasks are presented, in this case, it corresponds mainly to a numeric, pictorial and verbal language. Numerical related to numbering steps by a linear count, and cardinality, not exceeding ten, and in the sequence of play, up to twenty. Verbal, because it is necessary to read commands and instructions. Finally, pictorial, because of the animation of the labyrinth itself. The use of 3 simultaneous codes will activate the flexibility for the ability to analyze and decode information. A mediation instance for non-readers is still the global reading, which associates the word with a symbol / command: forward, rotate, repeat (iterate), logical conditionals (if [condition] then [action]).

Capabilities or Mental Operations

The main operations and in increasing order of complexity required by the task refer to:

• Comparison, where the relations of similarities and differences between the labyrinth itself and the commands that are written to complete the route, must be determined permanently in the game. This operation is activated by verifying step v/s the path v/s command.

• Coding is a way of relating languages with their corresponding signs. This enables flexibility and synthesis by internalizing the numeric, verbal, pictorial and figurative signs, which are synonymous with the work of syntax and semantics of text-based programming.

•The use of virtual relationships activates this mental capacity, which consists in seeing and establishing relations between external stimuli; relationships that do not exist in reality, but only potentially; this is what happens when imagining and creating a formula of the trajectory, necessary to reach the end of the labyrinth

•Transitive reasoning is the ability to order, compare, and describe a relationship in order to reach to a conclusion. It is a property of logic. Thus, in HoC-AB, the student, when elaborating a sequence through the comparison and the relation between commands, is able to draw a favorable conclusion or not, to reach the objective of the labyrinth.

• Hypothetical reasoning is the mental ability to make inferences and predictions from known facts, and the laws that relate them. In the HoC-AB, when selecting a command, the brain projects or visualizes a potential response in the construction of the trajectory.

Cognitive functions

Cognitive functions are the steps that underlie mental abilities or operations. According to the development phase of the response, there are mainly:

-INPUT PHASE: it is important to carefully explore the data to be used to operate, among which we find: words, drawings, positions, numbering, commands. Then it is important to manage student impulsiveness to control trial-error procedures, avoiding frustration and cognitive overload, while promoting strategic reasoning.

The functions referred to the use of verbal tools, should be ordered and classified, mainly those of topological-spatial type. Students should have a space, prior to the start of the game, to recognize, sort, classify, and internalize the information they will use. Consequently, the HoC requires a continuous and simultaneous processing of different information, for which - if properly identified and categorized - it will allow a better handling of symbols, positions, assessments, directions, simultaneously. It is here where strategies of targeting, exploration, registration and order are necessary.

-PREPARATION PHASE: At this stage or level, it is important to encourage the autonomy of comparative behavior, so that the identification and use of criteria allow the student to expand the internalization skills required by this game, controlling different information. For this, it is necessary to distinguish the relevant aspects from the less relevant ones. It could be that more concrete children tend to focus more on the animation of the labyrinth than on scheduling. Retro-stimulation should then be granted in relation to the definition of the task of labyrinths, that is, programming to perform the necessary paths or trajectories.

The parameter of complexity gives to this labyrinth task a progressive level, and for this it requires an internalized behavior. That is, to achieve the highest mental representation, to plan and establish the necessary logical relationships. The internalized behavior is enhanced using verbal tools and symbols. One strategy is to suspend, during the planning of the trajectory, the visual stimuli of the screen, so they do the planning in a verbal way.

Another function of the elaboration phase refers to the development of the planned behavior required by the HoC. This is related to impulsivity. The steps must be projected according to a certain degree of detail, and ordered according to the temporal sequence. On the other hand, they must be evaluated based on the investment, the feasibility, the economy, among other important criteria for the student.

Finally, the cognitive function of elaboration, called summative behavior, will affect the planning visualized in the necessary steps and categorized to proceed to formulate a response in the form of a program.

-OUTPUT PHASE: One of the cognitive functions is the control of impulsivity. Generally, it can happen, when the support of verbal resources is subtracted when emitting a plan of the trajectory, relegating it to the intuition. Another aspect is the obstruction that the student can experience when they don’t find a solution, or when they don’t receive feedback from the game, tending to try and try possible answers, but without a logical basis, away from the objective of the challenge, which is to develop computational thinking and programming.

Another cognitive function of the elaboration is the projection of virtual relationships, that is, those that have been constructed and elaborated, but that must be projected to give a precise answer. This may involve the restructuring of a given set of instructions, typical during the execution, in addition it must understand the error that can be experienced, and the step-by-step review of the planning.

Chip coins for each labyrinth

Each labyrinth has a chip coin that explains the studied variables, in the same way that they offer the solution of each one of the challenges.

LEVEL 1

Prerequisites:

- Word reading
- Linear count
- Following instruction

Contents

- Spatial orientation
- Work planning

Complexity:

- Low: straight way

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Attentive stimuli observation, considering the four execution plans: INDICATOR OF NUMBER OF TASK - COORDINATES PLAN – INSTRUCTIONS OR WORK BLOCK – ANSWER OR WORK SPACE OR WHEN EXECUTED.
- Command meaning or instructions: move forward, turn left, turn right.
- Sign recognition: eye movement of red angry bird, indicates direction.
- Reproduction with and without visual aid on the way.
- Verification of work plan. Consider recording the plan before executing it. (For example, writing the way on a personal board).
- With impulsive children, check their answer hypothesis.

Intervention of challenge emotions implicit in the game.

Method

- Written verbal,
- Numerical,
- Pictorial,
- Figurative, way blocks.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Projection of virtual relations.

Verbal Tools

- Number of steps
- Position
- Notions of space and time orientation
- Colors
- Straight way
- Prepositions: from, to.

LEVEL 2

Prerequisites:

- Word reading
- Linear count
- Following instructions

SOLUTION

Contents

- Spatial orientation
- Work planning

Complexity:

- Low: straight way

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Intervention Strategies

- Attentive stimuli observation, considering the four execution plans: INDICATOR OF NUMBER OF TASK - COORDINATES PLAN – INSTRUCTIONS OR WORK BLOCK – ANSWER OR WORK SPACE OR WHEN EXECUTED.
- Command meaning or instructions: move forward, turn left, turn right.
- Sign recognition: eye movement of red angry bird, indicates direction.
- Reproduction with and without visual aid on the way.
- Verification of work plan. Consider recording the plan before executing it. (For example, writing the way on a personal board).
- With impulsive children, check their answer hypothesis.

Intervention of challenge emotions implicit in the game.

Method

- Written verbal,
- Numerical,
- Pictorial,
- Figurative, way blocks.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Projection of virtual relations.

Verbal Tools

- Number of steps
- Position
- Notions of space and time orientation
- Colors
- Straight way
- Prepositions: from, to.

LEVEL 3

SOLUTION

Prerequisites:

- Word reading
- Linear count
- Following instructions
- 90° turn

Contents

- Spatial orientation

Complexity:

- Low: incorporates one 90° turn.

Intervention Strategies

- Identification of distractions.
- Plan turns to the left, turns to the right.

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Method

- Written verbal,
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Projection of virtual relations.

Verbal Tools

- 90° turn
- Left, right in regards to another.

LEVEL 4

Prerequisites:

- Word reading
- Linear count
- Following instructions

Contents

- Spatial orientation

Complexity:

- Low: increases from 1 to 2 turns.

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of three or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Intervention of interiorized and planned behavior.
- Controlling impulsive behavior.
- Intervention of competitive feeling.

Method

- Written verbal,
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Projection of virtual relations.

Verbal Tools

- 90° turn
- Left, right in regards to another.

LEVEL 5

Prerequisites:

- Word reading
- Linear count
- Following instructions

Contents

- Spatial orientation

Complexity:

- Medium: introduction of new triangular figure that may interfere in the perception of the angry bird jump.

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Comparative intervention, equal dimension of quadrangular block, 1 is 1.
- Meaning intervention of use of rules and sequences that provide efficiency and accuracy in the answers.

Method

- Written verbal,
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Projection of virtual relations.

Verbal Tools

- Two 90° turns
- Left, right in regards to another.

LEVEL 6

Prerequisites:

- Word reading
- Linear count
- Group multiplication

Contents

- Spatial orientation

Complexity:

- Medium: in the instructions, a new pink multiplier block is introduced.
- It is required to apply hypothetical thinking to switch values.
- 5 steps = 5v multiplier.

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Observe and relate the pink multiplier block, anticipating execution.
- Rehearse possible ways with switch.
- Retention intervention.

Method

- Written verbal,
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical thinking
- Projection of virtual relations.

Verbal Tools

- Simple straight line.

LEVEL 7

Prerequisites:

- Word reading
- Linear count
- Group multiplication

Contents

- Spatial orientation

Complexity:

- Medium: in the instructions, a new pink multiplier block is introduced.
- It is required to apply hypothetical thinking to switch values.
- 5 steps = 5v multiplier.

Cognitive Functions:

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Observe and relate the pink multiplier block, anticipating execution.
- Rehearse possible ways with switch.
- Retention intervention.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical thinking
- Projection of virtual relations.

Verbal Tools

- Simple straight line.

LEVEL 8

SOLUTION

Prerequisites

- Word reading
- Linear count
- Group multiplication

Contents

- Spatial orientation

Complexity

- Medium: multiplier block and simple turn.

Intervention Strategies

- Interventions of task rules.
- Sequence and verification procedure selected with multiplier number.
- Favor insight over process done.

Cognitive Functions

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical thinking
- Projection of virtual relations.

Verbal Tools

LEVEL 9

Prerequisites

- Word reading
- Linear count
- Group multiplication

Solution

Contents

- Spatial orientation
- Change

Intervention Strategies

- Intervention over regulation of impulsiveness before previously used rule.

Complexity

- Low: use of one simple multiplier.

Cognitive Functions

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical thinking
- Projection of virtual relations.

Verbal Tools

LEVEL 10

Prerequisites

- Word reading
- Linear count
- Group multiplication

Solution

Contents

- Spatial orientation
- Change

Intervention Strategies

- Intervention over competitive and autonomy feeling, to control and dominate multiplier variation.

Complexity

- Medium: pictorial multiplier related to the pig's objective, not numerical.

Cognitive Functions

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding of virtual relations projection.

Verbal Tools

LEVEL 11

Prerequisites

- Word reading
- Linear count
- Group multiplication

Contents

- Spatial orientation
- Change

Complexity

- Medium: pictorial multiplier related to the pig's objective, not numerical.

Cognitive Functions

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Intervention over competitive and autonomy feeling, to control and dominate multiplier variation.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding of virtual relations projection.

Verbal Tools

LEVEL 12

Prerequisites

- Word reading
- Linear count
- Group multiplication

Contents

- Spatial orientation
- Change

Complexity

- Medium: discover that it is possible to change pictorial multiplier factor.

Cognitive Functions

Input:
- Precise perception of the stimuli.
- Consideration of two or more simultaneous information sources.
- Use of spatial and temporary models.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Mediate meaning over possibility to achieve flexibility changes in task behavior due to internalization of rules and sequences.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Virtual relations projection.

Verbal Tools

- Zombie
- Straight line.

LEVEL 13

Prerequisites

- Instructions reading
- Attention to change of position of mobile.

Contents

- Spatial orientation
- Change

Complexity

- Low

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Mediation to protect perceptive determination of mobile objects before position change.
- Suggested questions: who do you have to hunt? Who is the hunter? Where are they?

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Virtual relations projection.

Verbal Tools

LEVEL 14

Prerequisites

- Instructions reading
- Defining new operating block if…
- Understand conditional tense.

Contents

- Spatial orientation
- Change
- Conditional

Complexity

- Medium: it is necessary to achieve mental representation of what the new block implies.

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Mediation centered in blocks and execution space, where planning behavior must be reinforced, using verification questions about the steps to follow. Why don't I need a fixed number of steps?
Complexity starts to focus on the use of commands to set programming. The user must organize and include a command over another, which is first and what is its content.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Virtual relations projection.

Verbal Tools

- "If" conditional block.

LEVEL 15

Prerequisites

Contents

Complexity

- Medium - High: due to the incorporation of pink step multiplier block.

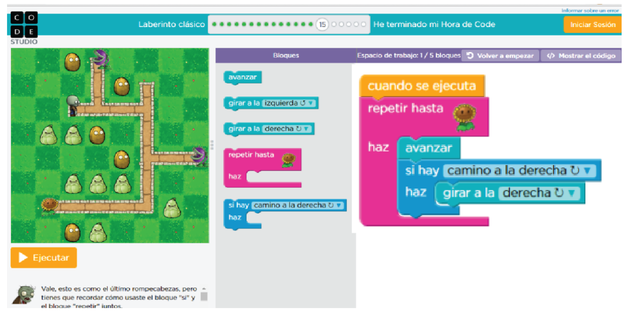
Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION



Intervention Strategies

- Mediation of simultaneous control of variables. How many aspects must be considered? How can they be organized? Which should contain which?

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Inclusion
- Virtual relations projection.

Verbal Tools

LEVEL 16

SOLUTION

Prerequisites

- Use of conditional

Contents

- Spatial orientation
- Change
- Conditional

Complexity

- Medium: change of mobile characters and objective.
- 17 change of direction.

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Intervention Strategies

- This task can be considered as a reinforcement for complexity change of number 15, and allows autonomy of executer.
- In children younger than 10 years old, allow trial and error up to 3 times and then reflect on it, analyze the type of error that appears, which repeats and what it represents.
- Lack of planning
- Not all variables have been considered
- Less exploration
- Less movement internalization
- P17 exploring and proceeding to change direction in conditional operator.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Inclusion
- Virtual relations projection.

Verbal Tools

LEVEL 17

Prerequisites

- Use of conditional

Contents

- Spatial orientation
- Change
- Conditional

Complexity

- Medium: change of mobile characters and objective.
- 17 change of direction.

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- This task can be considered as a reinforcement for complexity change of number 15, and allows autonomy of executer.
- In children younger than 10 years old, allow trial and error up to 3 times and then reflect on it, analyze the type of error that appears, which repeats and what it represents.
- Lack of planning
- Not all variables have been considered
- Less exploration
- Less movement internalization
- P17 exploring and proceeding to change direction in conditional operator.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Inclusion
- Virtual relations projection.

Verbal Tools

LEVEL 18

Prerequisites

- Use of conditional

Contents

- Spatial orientation
- Change
- Conditional

Complexity

- Medium – High: due to double conditional, if there is or if there is not.

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Intervention.
- Practice of "if not" conditional is important to build the way.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Inclusion
- Virtual relations projection.

Verbal Tools

LEVEL 19

Prerequisites

- Use of conditional

Contents

- Spatial orientation
- Change
- Conditional

Complexity

- Medium – High: due to double conditional, if there is or if there is not.

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

SOLUTION

Intervention Strategies

- Intervention.
- Practice of "if not" conditional is important to build the way.

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

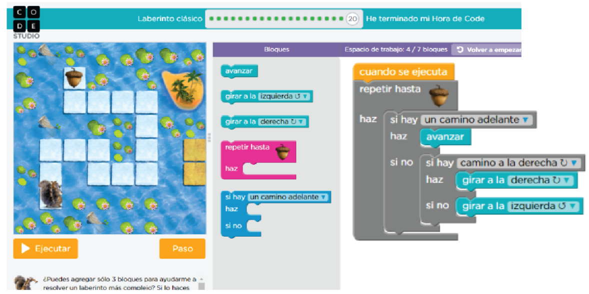
Operations

- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Inclusion
- Virtual relations projection.

Verbal Tools

LEVEL 20

SOLUTION



Prerequisites

Contents

- Spatial orientation
- Change
- Conditional

Intervention Strategies

- Complexity is focused on coordinating simultaneously the different commands, organizing the steps.
- Since there is a fixed outline to be followed, user's less flexibility may interfere to virtually code the requested plan.

Complexity

- Medium – High
- Use of triple conditional with change of direction.

Cognitive Functions

Input:
- Precise perception of new stimuli.
- Consideration of more than two simultaneous information sources.
- Use of spatial and temporary models.
- Perceptive persistence.

Elaboration:
- Task definition
- Comparative behavior
- Perceptive determination
- Summative behavior
- Interiorized behavior
- Preparation of a work plan.

Output:
- Use of virtual relations
- Impulsiveness control
- Precision and accuracy in response communication
- Visual transportation

Method

- Written verbal
- Numerical, cardinal
- Pictorial.

Operations

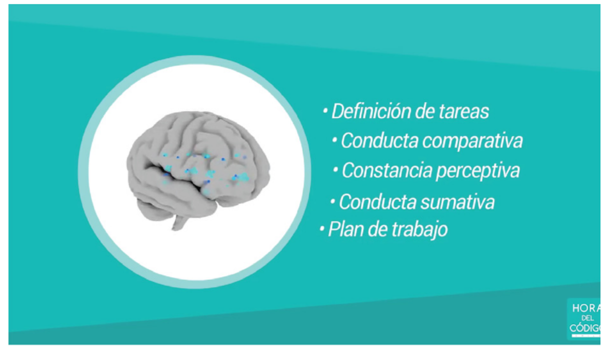
- Identification
- Comparison
- Analysis and summary
- Coding
- Hypothetical reasoning
- Inclusion
- Virtual relations projection.

Verbal Tools

Making the Hour of Code

As we have seen, HoC is not just about programming, there is also an opportunity for our students to develop their higher cognitive skills. As part of the Hour of Code campaign, a series of preparations and workshops were held. Teachers from different parts of the country asked questions about this initiative, interested in being able to effectively conduct the HoC with educational value in their schools. Some of their concerns were: How are we going to give the instructions? How many programs do they manage to develop and for how long? Is there a difference between men and women? What special support should we give to the less advanced students in math? What kind of questions do the students ask?

In the region of Panquehue, and coordinated with the local City Hall, we invited 204 students from 4th to 8th grade, to develop the HoC in a computer lab. Although the initiative is called Hour of Code, teachers are in charge of establishing the time for students to develop the educational experience by solving the challenges. For the purpose of this study, participants were given 30 minutes. Our focus is not to measure how many were able to finish, but the process of doing the HoC within a certain amount of time that allows concentration and interest.



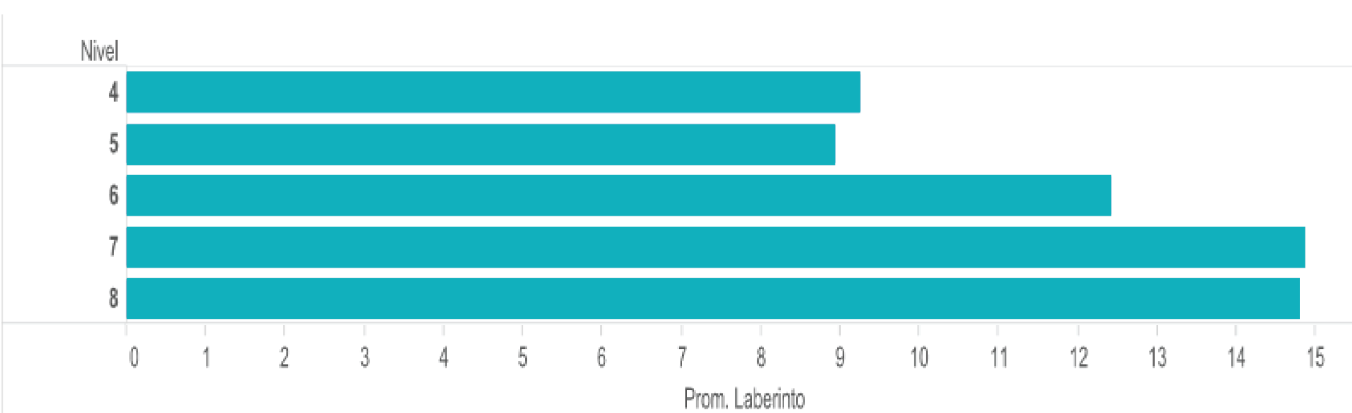
How are we going to give instructions?

First, we show a 4-minute video tutorial explaining how to proceed and what the goal is. While for the 6th, 7th and 8th grade students the instructions presented in the tutorial video are sufficient, some 4th and 5th grade students need to review, even make the first 2 out of the 20 programs so that students understand what they have to do. Students start making questions 10 minutes after they have started working.

How many programs do they manage to develop and how long does it take to manage them?

There is no defined time to develop the Hour of Code, considering that the important thing is not only to complete the 20 labyrinths but, the process that means solving them. Figure 1, shows the average number of labyrinths solved according to each level. The children of 7th and 8th grades, show a greater number of labyrinths solved, with an average of 15.

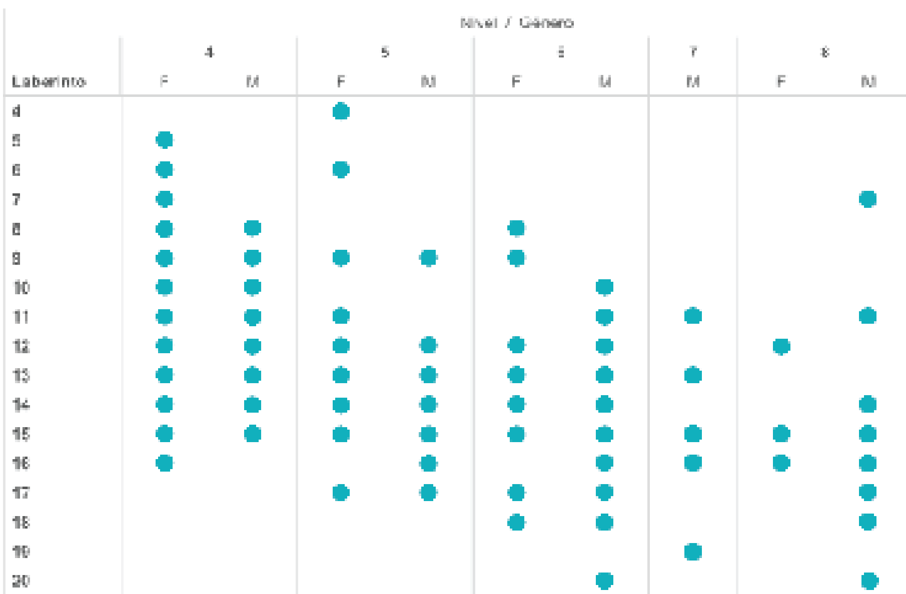
Graph 1
Average number of labyrinths solved per level



Is there any difference between men and women?

There were no significant difference between men and women regarding their participation in the HoC; they show similar interest, interaction and achievement. For example, as shown in figure 2, in 4th grade, women (W) have greater variability of results. They are the ones that made the most progress, but also the ones that did less programs. In 5th grade, there are members of both groups who managed to reach program 17. In 6th grade the behavior is similar, the most advanced ones completed 18 challenges, except for a student who reached 20. In the 7th grade, there were no women participating. In 8th grade, we began to see gender differences, where men showed slightly better results.

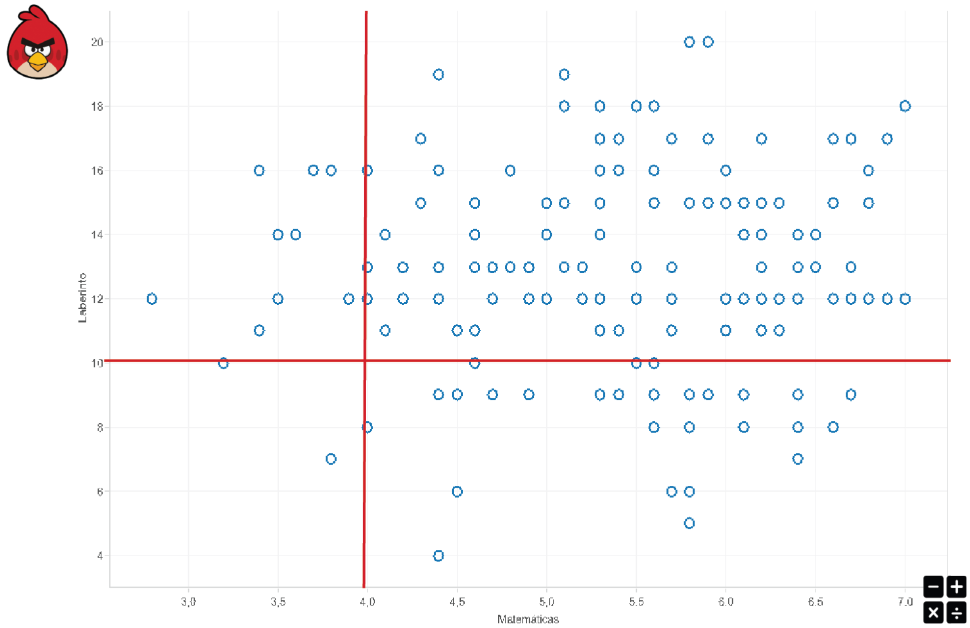
Graph 2
Number of programs solved by level and gender



What special support should we give to math's less advanced students?

Performance in math, a subject commonly associated with programming skills, is not directly related to the number of labyrinths solved during the same amount of time, as seen in figure 3. In the X axis, are the math grades obtained by students during the first semester of 2016. In Y axis, are the number of solved labyrinths, from 1 to 20. The red lines intersect the X axis in the minimum passing grade, while they intersect the Y axis in the middle of the labyrinths possible to solve. In 30 minutes, almost all students managed to solve more than half of the labyrinths, even those with a grade below 4.0 in math. There are also students who have had a poor performance in the subject and yet managed to solve more challenges than the average participants.

Graph 3
Grades in math vs. the number of programs solved



What kind of questions do the students ask?

Table 1
Main students' questions

Type of questions	Game commands	Assistance	Lack of comprehension
Expression examples	- How do I make it turn? - How do I make it move forward? - How do I make it turn left/right? - How do I put a block inside another block?	- I'm trying but I can't. - Can you help me? - Can you help me to make it turn? - I did it once and it won't keep moving.	- I don't understand. - I can't move forward. - I can't. - I don't know how to make it repeat. - I don't know how to use the repeat block.

This more qualitative dimension of the dynamics, shows the centrality that the teacher acquires in the classroom, as a mediator that allows to direct and to channel the understanding, and mental exercise of the student. For example, procedural questions, at the command level “how do I make it turn? How do I make it turn left/right? How do I move forward? “, are instances to work the capacity of spatial perception, and abstraction of steps.

The same is unfolded in logical type questions such as “how can I make it repeat itself? Why does it restart? “, Which work the concept of iteration (or loop) proper of programming, that require a guide work on the thinking process, or mental models generated by the student.

Finally, it also shows a space to mediate frustration and resilience. Many students say “I can´t, I have done it several times .... Something is wrong, I have tried a lot of times ... “, this is something common in programming environments, and it requires great concentration, attention, and patience abilities, the position of the mediator here is key in leading the students to rethink their actions, and understand what and how it is operating to reach such an outcome, and to re-focus them on solving the problem.

Conclusion

Participating in the HoC is a good doorway to Computational Thinking and a tool of great educational value. Knowing how to program is beneficial, on the one hand, because it provides the necessary elements to face the challenges of the Knowledge Society; and on the other, because different studies have shown their relationship with the development of higher order cognitive abilities. However, less attention has had the following question: What do we actually do when we program? A very important topic from the point of view of teaching, and which answer we seek to approach through the HoC.

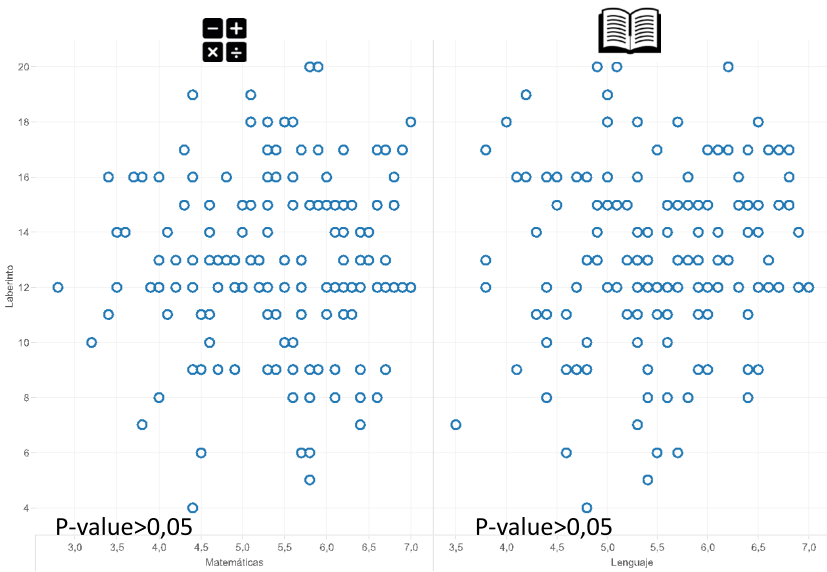
In the first part, we analyze what underlies the task of doing the HoC, the modality, the content, the mental operations, the cognitive functions, the level of abstraction and the level of complexity that the students face. This aims at offering the teacher a guide to recognize the levels of change that students can experience in learning and the requirements they can present to stimulate the exercise of metacognition: How am I thinking? What am I doing wrong? How did I discover the solution?

In the second part, through a case study, we showed that HoC is an adequate tool to develop workshops for students of different levels; that there are no gender differences in performance before 8th grade, which is where you notice a slight advantage in favor of men; that there are students with discrete performance in math and language subjects that achieve outstanding results in the development of HoC; among other findings.

This study will serve as a basis for developing new researches that aim at preparing training workshops for teachers, who form the HoC network of embassadors in Chile.

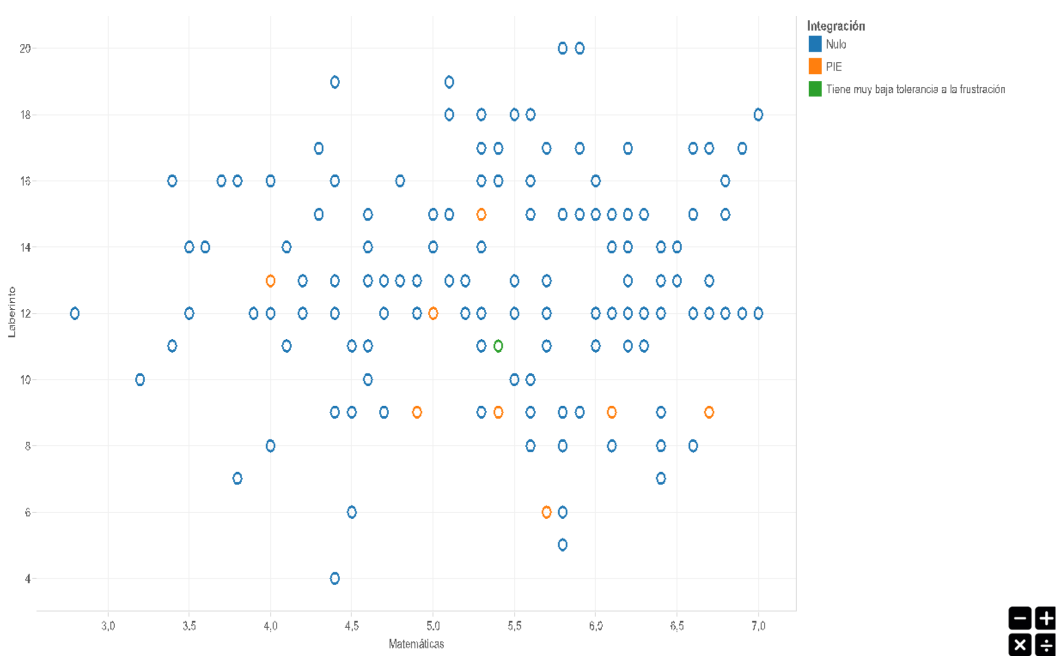
Annex

Annex Graph 1



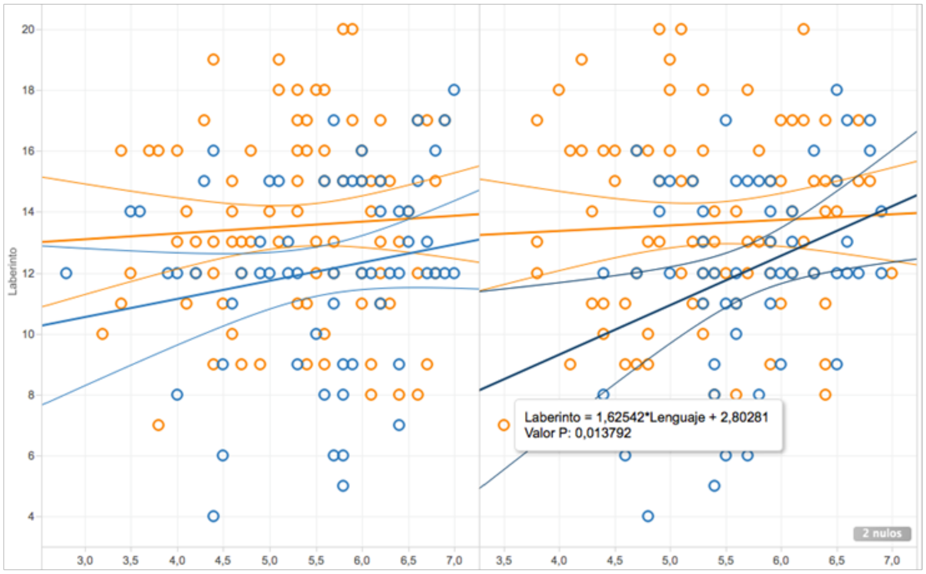
This graph shows grades in math and language, and performance in the labyrinth game. What we can appreciate is that there is no causal relationship between one element and another, that is, better or worse grades in language or math, do not explain the result in the game. This is reflected in P-value, that due to a statistical convention, it is said that if a p. Value is higher than 0.05, the results or associations between two or more variables are random.

Annex Graph 2
Note in math vs. number of programs solved
Students of the Special Integration Program (SIP)



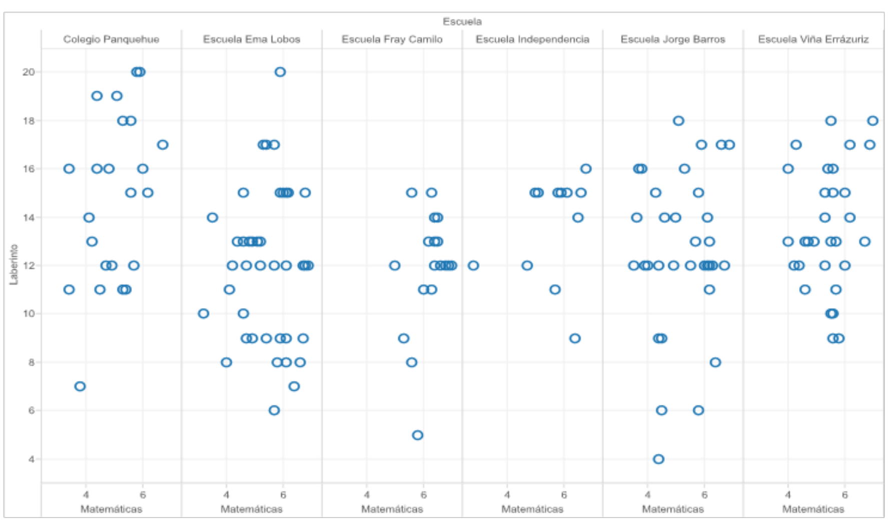
This graph shows that performance in math is also not a predictor of the results in the labyrinth game even for students of the PEI (colored dots), because it is possible to find SIP exponents that manage to solve more labyrinths than some of their peers with better math scores.

Annex Graphic 3
Note in math vs. Number of programs solved by man (orange) and women (blue) for both Mathematics (left) and Language (right).



This graph reinforces the idea that performance in math is not a predictor of the ability to solve labyrinths. However, there is a positive association between language performance and labyrinths when gender division is included, benefiting women. That is, women who have a good level of language tend to have better results in solving labyrinths (note that the value is less than 0.05, that is, the result is not random), this may be due to the fact that they are dedicated to read the instructions before programming the commands.

Annex Graphic 4
Performance in mathematics and labyrinth by establishments



Finally, the school effect does not generate a better link between grades and performance in the game, as shown in figure 4, in this, it can be seen that even in schools where there are better students, with grades 6 or higher, they do not manage to complete more labyrinths than their peers with the same scores in other schools. In addition, in the schools that have a better results in the number of completed labyrinths, this indicator does not appear related to the performance in mathematics, as it is the case of establishments 1, 5, and 6.

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