

MATH RACE



STEMJAM Teaching Guide

Developing make spaces to promote creativity
around STEM in schools

Acronym: STEMJAM

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MATH RACE

ABSTRACT

The idea is to create a "math race" in between two mBots, commanded by two students' teams.

On first version, the main goal of activity is writing a program using:

- ❖ Variables
- ❖ Generating random numbers
- ❖ New block defined by student (also with parameter)

Students will solve Math problems of different level of difficulty, (such as solving linear equations with an unknown, second degree equations, and systems of linear equations with two unknowns). The solutions given by the students will generate reactions in the robots, which will interact with each other showing different effects (sounds, lights, etc.).

Each robot will win "life", if its team gives the correct answer. But, they also will lose "life" every time the team gives a wrong answer.

DIDACTIC OBJECTIVES

TECHNOLOGY

- ❖ Introduction to computational thinking.
- ❖ Assimilation, creation and programming of algorithms, to decompose complex problems into ordered sequences of simple instructions, which solve it.

MATHEMATICS

- ❖ Solving linear equations with an unknown.
- ❖ Solving second degree equations.
- ❖ Solving systems of linear equations with two unknowns.

STEM Subject: Science Technology Engineering Mathematics

Education Level: 12-14 years 14-16 years



PROBLEM STATEMENT

The mBot robot has to be programmed to work altogether with the laptop, by creating the operations' algorithms and the resultant effects. This way, when the students calculate the answer to one equation, there is a specific effect on the robot and so there is in the race.

To build a robot to make a competition between two teams. Thinking about difficulties of maths operations. The basic one is for children at the beginning of primary school. Next you can make the problem more complex - add division with rational result. At the end – solving linear equation.

BOM (Bill of Materials Needed)

- (x2) mBot => Ref. 90054



- ❖ (x2) Me 7-Segment Serial Display - Red:



- ❖ (x2) Me LED Matrix 8 × 16:



- ❖ (x2) Laptops.
- ❖ (x2) Calculators.
- ❖ (x2) Paper and pen.
- ❖ Starting and a finish line.
- ❖ Rest of Attrezzo (not essential).

ELEMENT	ID	CABLE	AMOUNT	PORT 1			PORT 2			PORT 3				PORT 4				P.MOT1	P.MOT2
				Am	Az	Bl	Am	Az	Bl	Am	Az	Bl	Ng	Am	Az	Bl	Ng		
Mbot Robot 2´4G			2																
Motor 1	Bl*															Bl*			
Motor 2	Bl*																Bl*		
Matriz de LEDs	Az	2	2		Az														
Display 7 segmentos (4 dígitos)	Az	2	2										Az						
RJ25 cables			4																
Structures																			
Support P1			2																
Cut-out beam			1																
Laptops			2																
Atrezzo (not essential)																			

ACTIVITY DESCRIPTION

First version

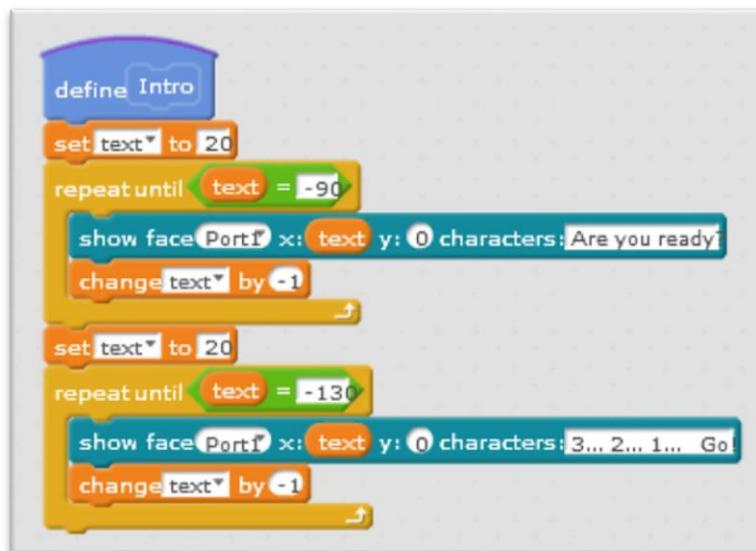
The aim of the activity is to practise Math exercises (such as solving linear equations with an unknown, second degree equations and systems of linear equations with two unknowns) by applying technological competences and working in a ludic environment.

This target will be achieved, since the students will have to design the programming blocks related to the robot's movement, as well as the different sound and dance effects for the activity.

Since programming needs to be designed so that a series of Math exercises lead of to another more difficult ones, mBlock software will be used for that purpose.

The first step is to start with PROGRAMMING tasks.

1. INTRODUCTION DEFINITION



```
define Intro
  set text to 20
  repeat until text = -90
    show face Portf x: text y: 0 characters: Are you ready
    change text by -1
  set text to 20
  repeat until text = -130
    show face Portf x: text y: 0 characters: 3... 2... 1... Go
    change text by -1
```

2. FIRST CHALLENGE DEFINITION: a simple equation



```
define Simpleequation
  set a to pickrandom -9 to 9
  repeat until not a = 0
    set a to pickrandom -9 to 9
  set b to pickrandom -9 to 9
  set c to pickrandom -9 to 9
  set x to (c - b) / a
  set Round "x" to round x * 100 / 100
  ask join Solve the following simple equation: join a join x join + join b join = c and wait
```

ACT04_~4.SB2

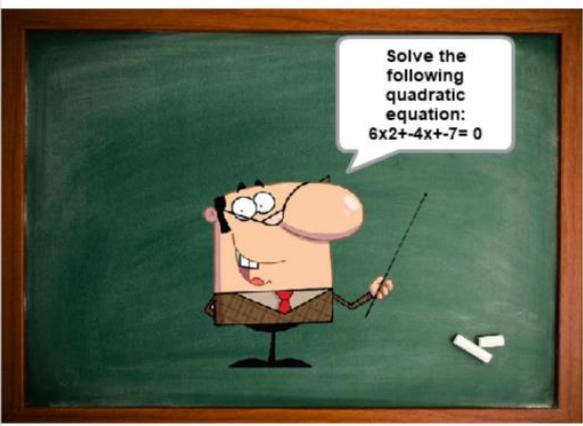
Solve the following simple equation:
 $3x+6=-4$

3. SECOND CHALLENGE DEFINITION: a quadratic equation

```

define QuadraticEquation
set a to pickrandom -20 to 20
repeat until not a = 0
  set a to pickrandom -20 to 20
set b to pickrandom -20 to 20
set c to pickrandom -20 to 20
repeat until sqrt of b * b - 4 * a * c > 0
  set a to pickrandom -20 to 20
  set b to pickrandom -20 to 20
  set c to pickrandom -20 to 20
  set x1 to (-1 * b + sqrt of b * b - 4 * a * c) / (2 * a)
  set x2 to (-1 * b - sqrt of b * b - 4 * a * c) / (2 * a)
  set Round "x1" to round x1 * 100 / 100
  set Round "x2" to round x2 * 100 / 100
say join Solve the following quadratic equation: join a join x join 2 join + join b join x join join + c join = 0 for 10 secs
ask Write "x1" value: ("+" solutio and wait
    
```

ACT04_~4.SB2



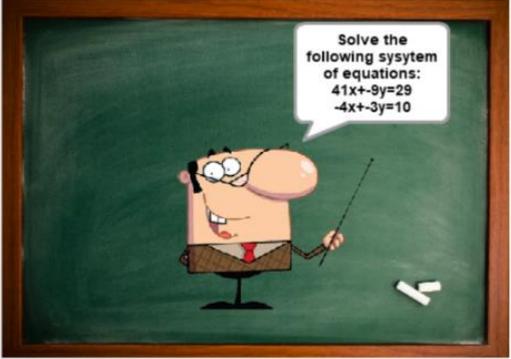
Solve the following quadratic equation:
 $6x^2 + 4x + 7 = 0$

4. THIRD CHALLENGE DEFINITION: a system of equations

```

define System of equations
set a to pickrandom 0 to 50
set b to pickrandom 0 to 50
set c to pickrandom 0 to 50
set d to pickrandom 0 to 50
set e to pickrandom 0 to 50
set f to pickrandom 0 to 50
set y to (a * f - d * c) / (1 * d * b + a * e)
set x(system) to (c - b * y) / a
set Round "y" to round y * 100 / 100
set Round "x(system)" to round x(system) * 100 / 100
say join Solve the following sysstem of equations: join a join x join + join b join y join + c join join d join x join + join e join y join + f for 10 secs
ask Write "x" value and wait
    
```

ACT04_~4.SB2



Solve the following system of equations:
 $41x - 8y = 29$
 $-4x - 3y = 10$

5. DEFINITION OF THE DIFFERENT “RIGHT ANSWER” ROUTINES:

- ❖ **“Right answer routine 1”**: performed when the team completes an equation successfully.
- ❖ **“Right answer routine 2”**: performed when the team completes the first unknown (“x1” from the second degree equation and “x” from the system of equations).
- ❖ **“Correct text”**: text performed during the “Right answer routines” when a team finds the right solution.

```
define Rightanswer routine 1
set led on board all red 0 green 255 blue 0
play tone on note G5 beat Eightff
play tone on note G5 beat Eightff
set led on board all red 0 green 0 blue 0
play tone on note G5 beat Eightff
set led on board all red 0 green 255 blue 0
play tone on note G6 beat Half
set led on board all red 0 green 0 blue 0
change Points by 10
set 7-segmentdisplay,Port7 number Points
"Correct" text
set motor M1 speed 255
set motor M2 speed 245
wait 2,6 secs
run forward at speed 0
```

```
define Rightanswer routine 2
set led on board all red 0 green 255 blue 0
play tone on note G5 beat Eightff
play tone on note G5 beat Eightff
set led on board all red 0 green 0 blue 0
play tone on note G5 beat Eightff
set led on board all red 0 green 255 blue 0
play tone on note G6 beat Half
set led on board all red 0 green 0 blue 0
"Correct" text
```

```
define "Correct" text
set text to 20
repeat until text = -5
show face Port7 x: text y: 0 characters: CORRECT
change text by -1
set text to 20
repeat until text = -5
show face Port7 x: text y: 0 characters: Go on
change text by -1
```

6. DEFINITION OF THE DIFFERENT “WRONG ANSWER” ROUTINES:

- ❖ **“Wrong answer routine 1”**: performed if the team does not develop correctly the simple equation.
- ❖ **“Wrong answer routine 2”**: performed if the team does not develop correctly the second degree equation.
- ❖ **“Wrong answer routine 3”**: performed if the team does not develop correctly the system of equations.
- ❖ **“Wrong text”**: text performed during the “Wrong answer routines” if a team does not find the right solution.

define Wrong answer routine 1

```
set led on board all red 150 green 0 blue 0
play tone on note F4 beat Quarter
set led on board all red 0 green 0 blue 0
set led on board all red 150 green 0 blue 0
play tone on note E4 beat Quarter
set led on board all red 0 green 0 blue 0
set led on board all red 150 green 0 blue 0
play tone on note D4 beat Half
set led on board all red 0 green 0 blue 0
change Points by -1
set 7-segmentsdisplay Port4 number Points
"Wrong" text
wait 1 secs
```

define Wrong answer routine 2

```
set led on board all red 150 green 0 blue 0
play tone on note F4 beat Quarter
set led on board all red 0 green 0 blue 0
set led on board all red 150 green 0 blue 0
play tone on note E4 beat Quarter
set led on board all red 0 green 0 blue 0
set led on board all red 150 green 0 blue 0
play tone on note D4 beat Half
set led on board all red 0 green 0 blue 0
change Points by -2
set 7-segmentsdisplay Port4 number Points
"Wrong" text
wait 1 secs
```

define Wrong answer routine 3

```
set led on board all red 150 green 0 blue 0
play tone on note F4 beat Quarter
set led on board all red 0 green 0 blue 0
set led on board all red 150 green 0 blue 0
play tone on note E4 beat Quarter
set led on board all red 0 green 0 blue 0
set led on board all red 150 green 0 blue 0
play tone on note D4 beat Half
set led on board all red 0 green 0 blue 0
change Points by -3
set 7-segmentsdisplay Port4 number Points
"Wrong" text
wait 1 secs
```

define "Wrong" text

```
set text to 20
repeat until text = -55
  show face Port1 x: text y: 0 characters: WRONG..
  change text by -1
set text to 20
repeat until text = -60
  show face Port1 x: text y: 0 characters: Try again
  change text by -1
```

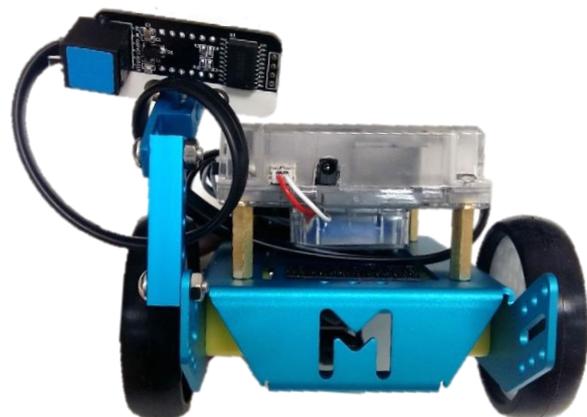
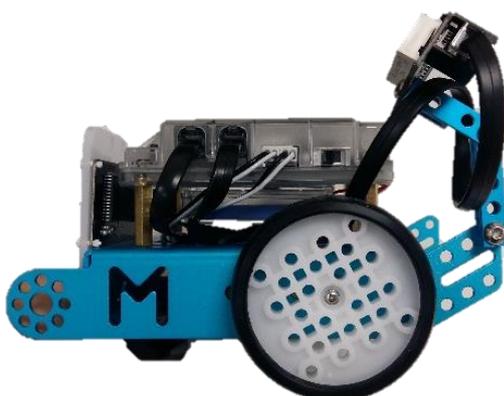
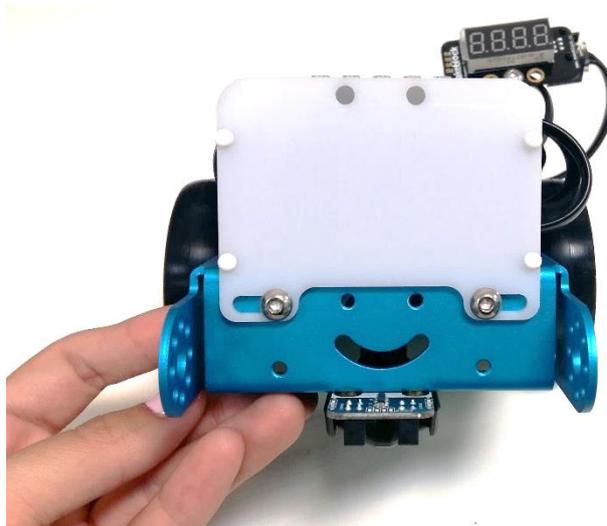
7. DEFINITION OF THE WINNER ROUTINE: performed when a team arrives to the finish line

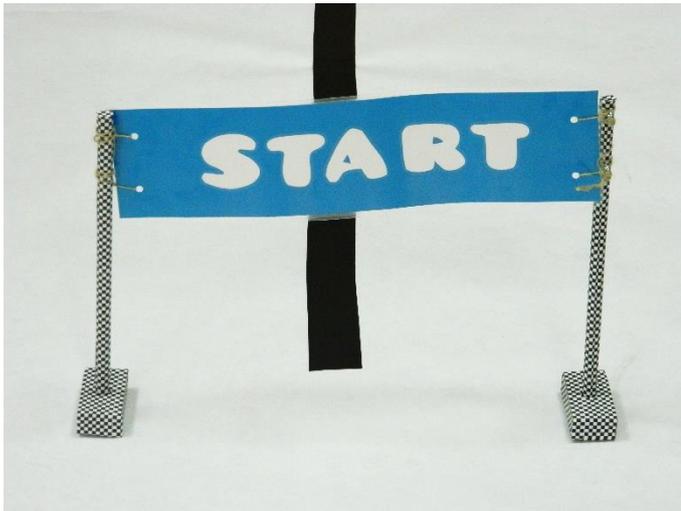
```
define Winner routine
  set text to 20
  repeat until text = -60
    show face Port x: text y: 0 characters Congrats..
    change text by -1
  set text to 20
  repeat until text = -55
    show face Port x: text y: 0 characters YOU WIN
    change text by -1
  repeat 2
    set led on board led left red 0 green 0 blue 255
    set led on board led right red 0 green 255 blue 0
    set motor M1 speed 100
    set motor M2 speed 100
    wait 0.5 secs
    set led on board led left red 0 green 255 blue 0
    set led on board led right red 0 green 0 blue 255
    set motor M1 speed -100
    set motor M2 speed -100
    wait 0.5 secs
    set led on board led left red 0 green 255 blue 255
    set led on board led right red 255 green 20 blue 20
    set motor M1 speed 100
    set motor M2 speed -100
    wait 0.5 secs
    set led on board led left red 255 green 20 blue 20
    set led on board led right red 0 green 255 blue 255
    set motor M1 speed -100
    set motor M2 speed 100
    wait 0.5 secs
    set motor M1 speed 0
    set motor M2 speed 0
    set led on board all red 0 green 0 blue 0
```

MAIN PROGRAMME: the sequence of the activity

```
when clicked
  set Points to 0
  set 7-segments display Port4 number Points
  Intro
  Simpleequation
  forever
    if answer = Round "x" then
      Right answer routine 1
      Quadratic equation
      forever
        if answer = Round "x1" then
          Right answer routine 2
          ask Write "x2" value: ("-" solution) and wait
          if answer = Round "x2" then
            Right answer routine 1
            System of equations
            forever
              if answer = Round "x (system)" then
                Right answer routine 2
                ask Write "y" value and wait
                if answer = Round "y" then
                  Right answer routine 1
                  Winner routine
                  stop all
                else
                  Wrong answer routine 3
              else
                Wrong answer routine 3
                System of equations
            else
              Wrong answer routine 2
          else
            Wrong answer routine 2
            Quadratic equation
          else
            Wrong answer routine 1
        Simpleequation
```

Once, the programming is finished, we start building up THE STRUCTURE, where all the mechanical elements will be set. Also the electronic elements.





Second version

The aim of activity is to build complex program, but this program should consist of subroutines and function to make it easier to control.

We start from the easiest version: Program gives the math operation to solve like addition, subtraction and multiplication numbers from 1 to 10.

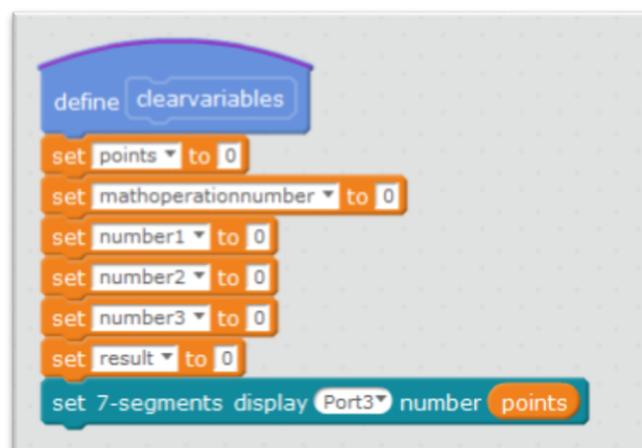
If the answer is correct the player receives one point, the robot go forward. There is the text "Correct" on the led screen.

Else the player loses one point. There is the text "Wrong" on the led screen.

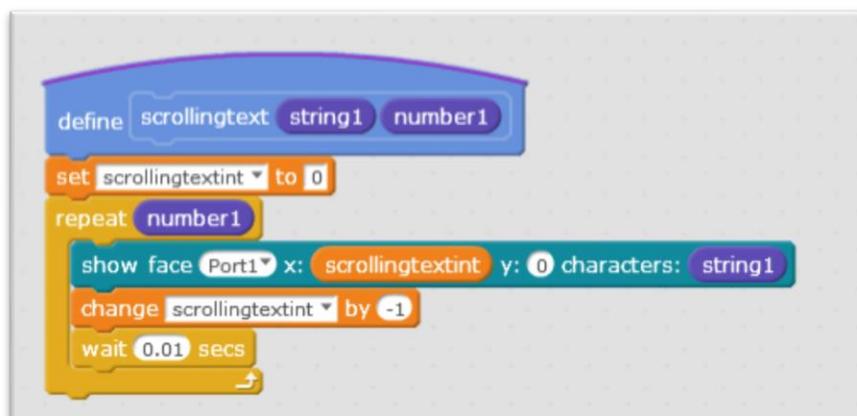
The program runs in forever loop

THE BASIC PROJECT: the basic program consist of four functions:

1. Function 1, which set variables to 0. It will be used at the beginning of program.



2. Function 2, which show on LED screen the inscription (string parameter). The parameter number 1 depends of length of the string.



```

define randommathoperation
  set mathoperationnumber to pick random 1 to 3
  set number1 to pick random 1 to 10
  set number2 to pick random 1 to 10
  set number3 to pick random 1 to 10
  if mathoperationnumber = 1 then
    set result to number1 * number2
    checkanswer join join number1 * number2
  if mathoperationnumber = 2 then
    set result to number1 + number2
    checkanswer join join number1 + number2
  if mathoperationnumber = 3 then
    set result to number1 - number2
    checkanswer join join number1 - number2

```

- The first action of the function Checkanswer is displaying the math operation on the screen of computer. This operation is passed as a string parameter. The computer wait for the player answer. Then it compares it with right answer and controls the robot (robot goes and show the text)

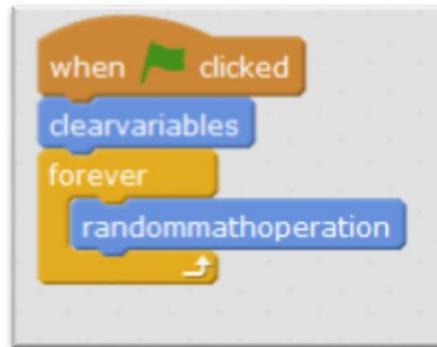
```

define checkanswer string1
  ask join What is the result? string1 and wait
  if answer = result then
    change Points by 1
    set 7-segments display Port3 number Points
    play tone on note C5 beat Half
    scrollingtext Correct! 47
    run forward at speed 100
    wait 3 secs
    run forward at speed 0
  else
    change Points by -1
    scrollingtext Mistake! 48
    play tone on note C3 beat Half
    set 7-segments display Port3 number Points

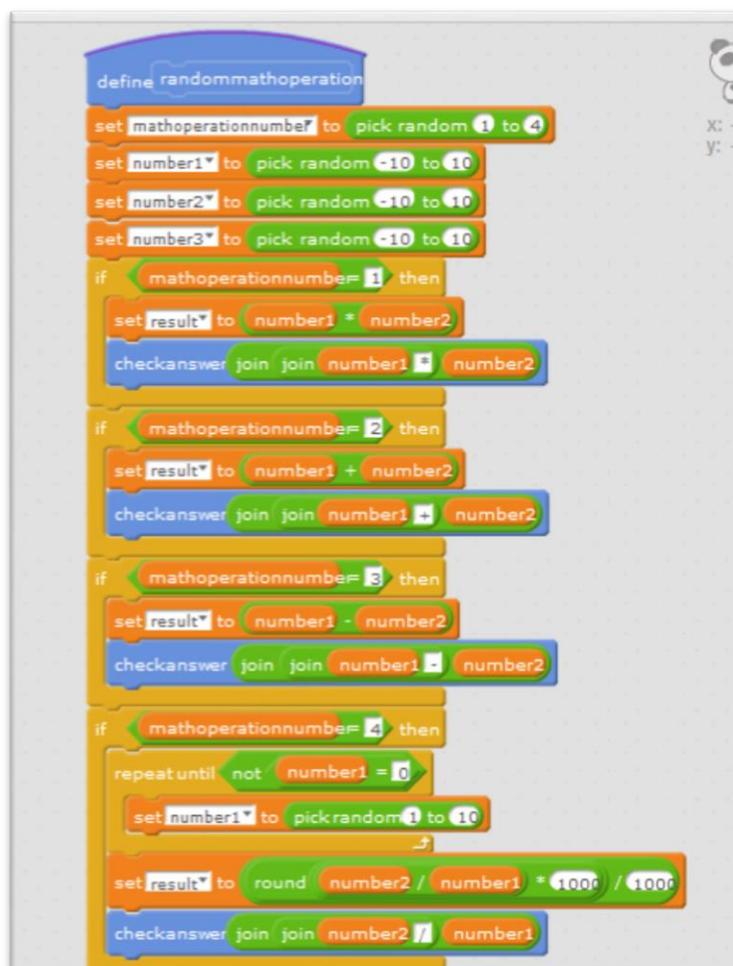
```

The main program is very short. The first instruction is clear variables.

Then we can put the function randommathoperation to forever loop.



Second Version: To randomoperation function we add next math operation – division. The difficulty is that the result could be rational number and we have to round the result.



We add fourth IF instruction. We have to also check divider – it can't be zero. In repeat loop we pick new divider, which is different from zero.

The result of division is rounded to 3 decimal place. The math operation is:

$$\text{Round}(\text{result} * 1000) / 1000$$

It is important for students to understand this construction, because it will be used in other programs.

Third version: Instead of simply math operation the student solve linear equation

$$ax + b = c$$

The a, b, c are numbers from the range -10 to 10

```
define randommathoperation
  set number1 to pick random -10 to 10
  set number2 to pick random -10 to 10
  set number3 to pick random -10 to 10
  repeat until not number1 = 0
    set number1 to pick random 1 to 10
  end repeat
  set result to round (number3 - number2 / number1 * 1000 / 1000)
  checkanswer join join number1 x join + join number2 join = number3
```

The solution is:

$$x = \frac{c - b}{a}$$

We need to round the result. In this exercise student built the more complex expression. The sequence of operation is realised by nesting instruction. This could be difficult.

Fourth version: We define the ending of the race. This time we use ultrasonic sensor. When the robot is near the wall the robot finish the program and show the statement "YOU WON"

```
define checkanswer string1
  ask join Solve the equation (round to 3 decimal points if necessary) string1 and wait
  if answer = result then
    change points by 1
    set 7-segments display Port3 number points
    play tone on note C5 beat Half
    scrollingtext Correct! 47
    run forward at speed 100
    wait 3 secs
    run forward at speed 0
    if ultrasonic sensor Port4 distance < 28 then
      say YOU WON
      play tone on note C4 beat Half
      play tone on note C5 beat Half
      play tone on note C6 beat Half
      scrollingtext You won! 50
      stop all
    else
      change points by -1
      scrollingtext Mistake! 48
      play tone on note C3 beat Half
      set 7-segments display Port3 number points
```

There are other options to end the race. For example, the race finished when the player gets 10 points.

Once, the programming is finished, we start BUILDING UP THE STRUCTURE where all the mechanical elements will be set, just as the electronic elements

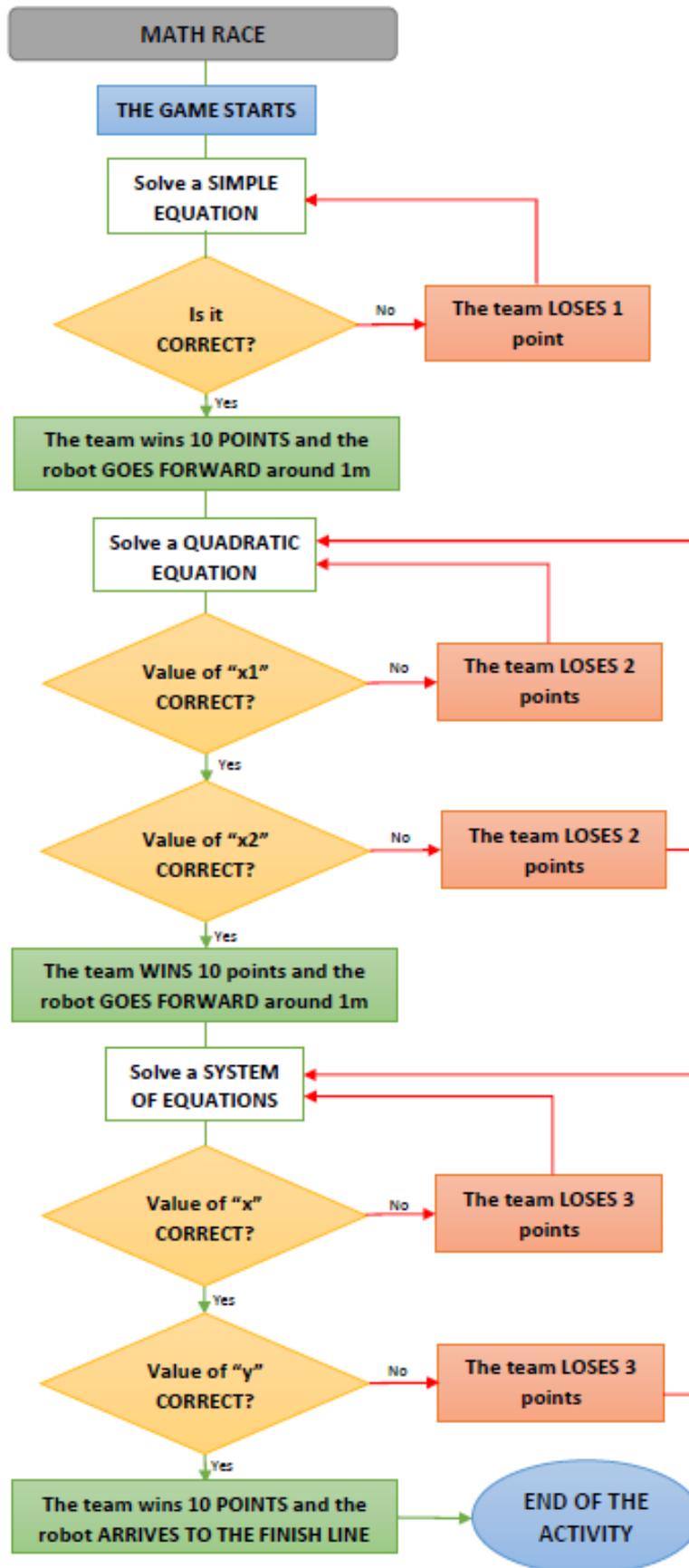


The math race in primary school:

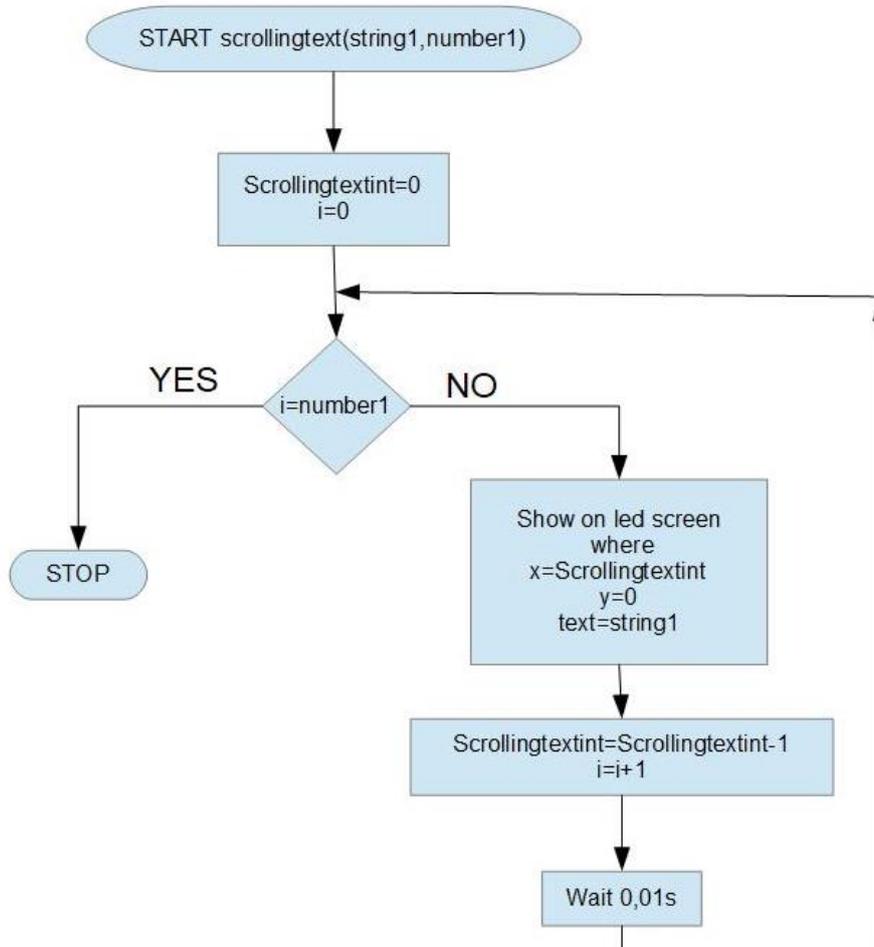
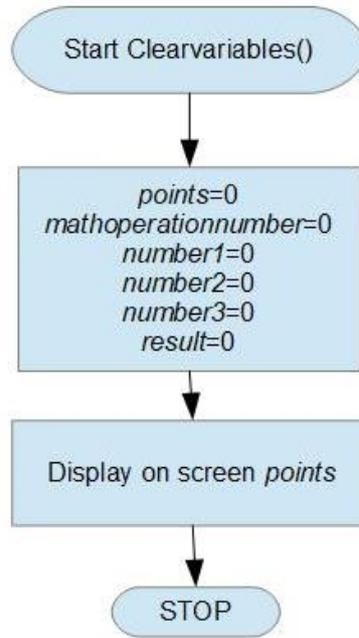


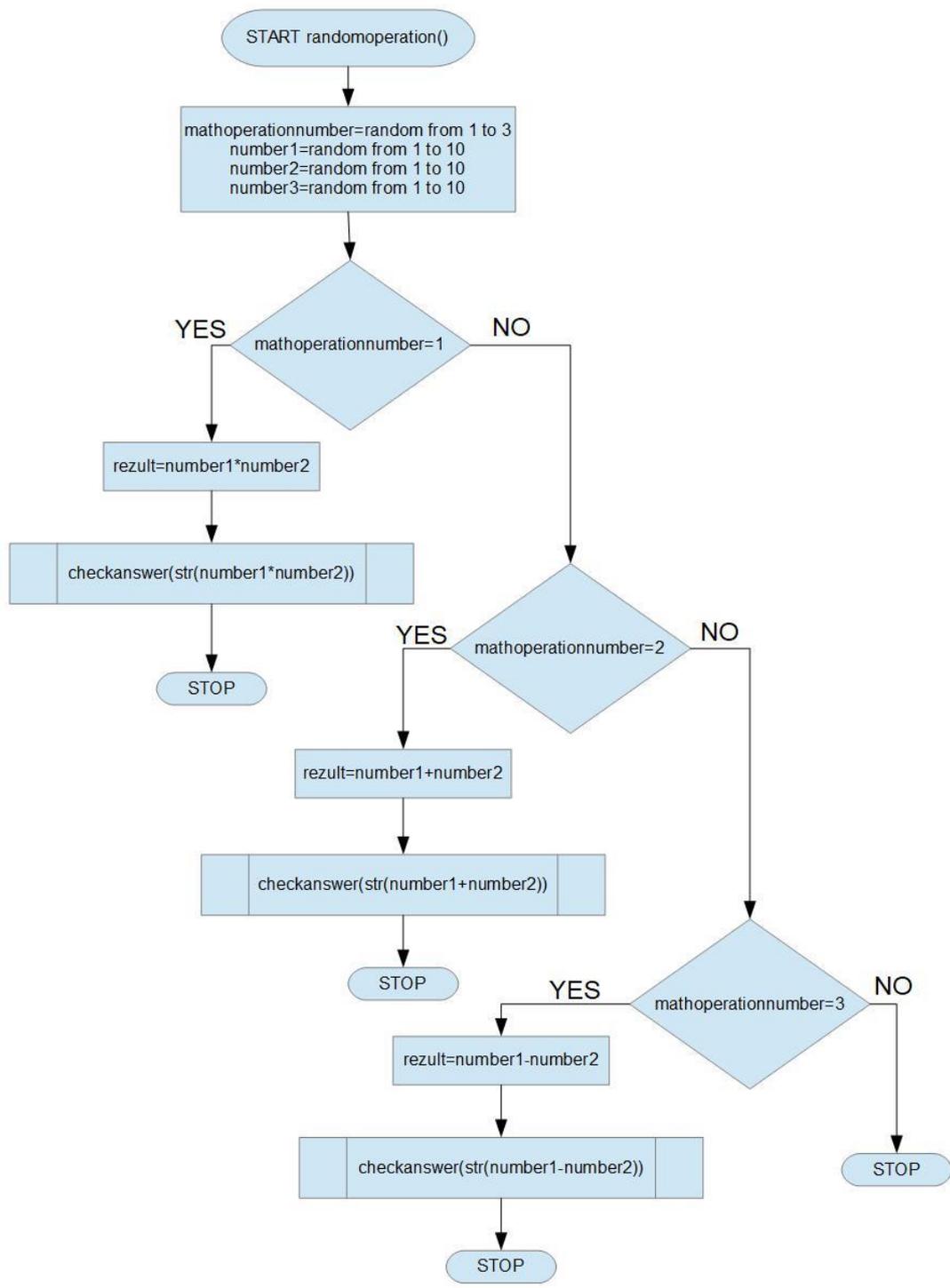
FLOW CHART

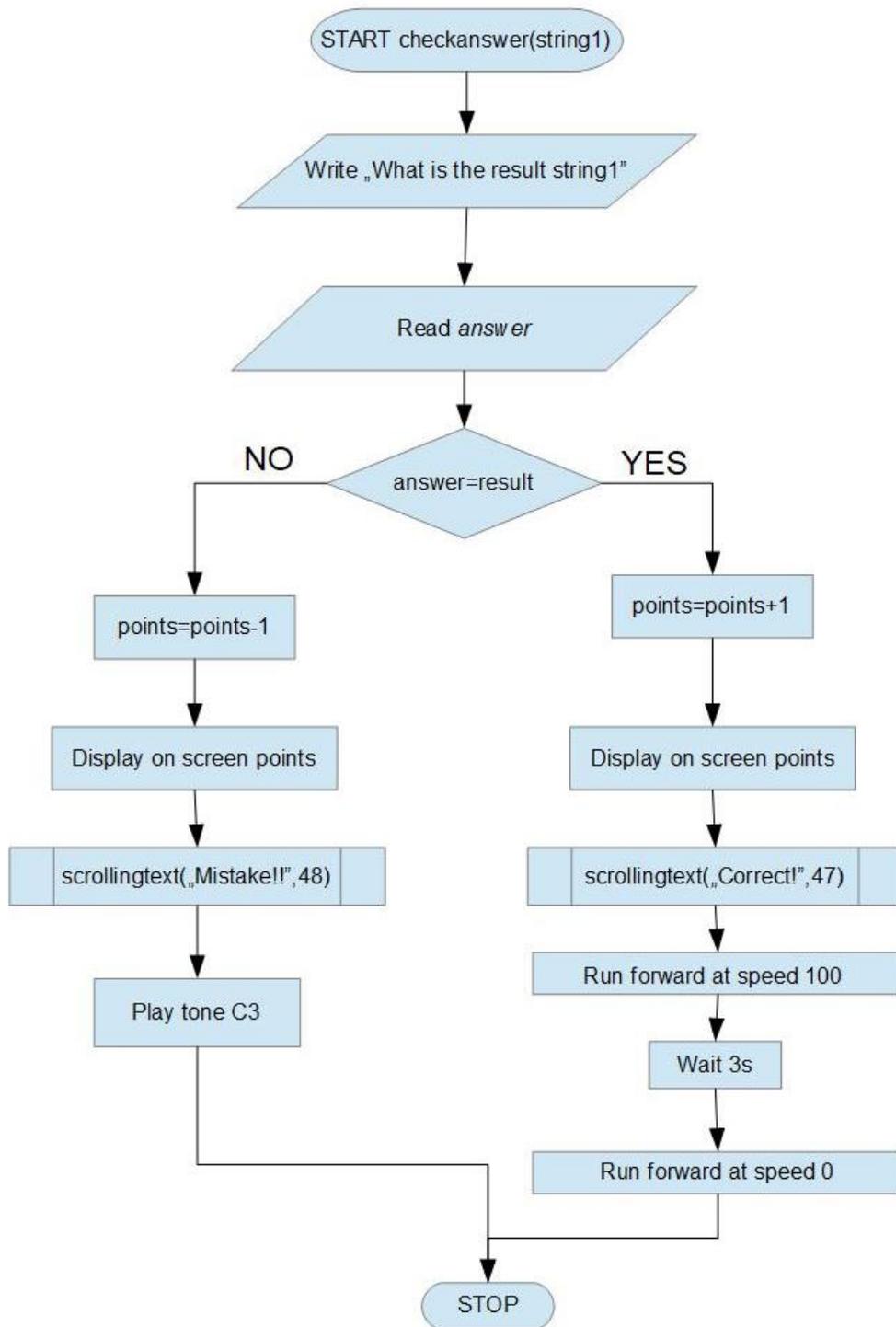
First version

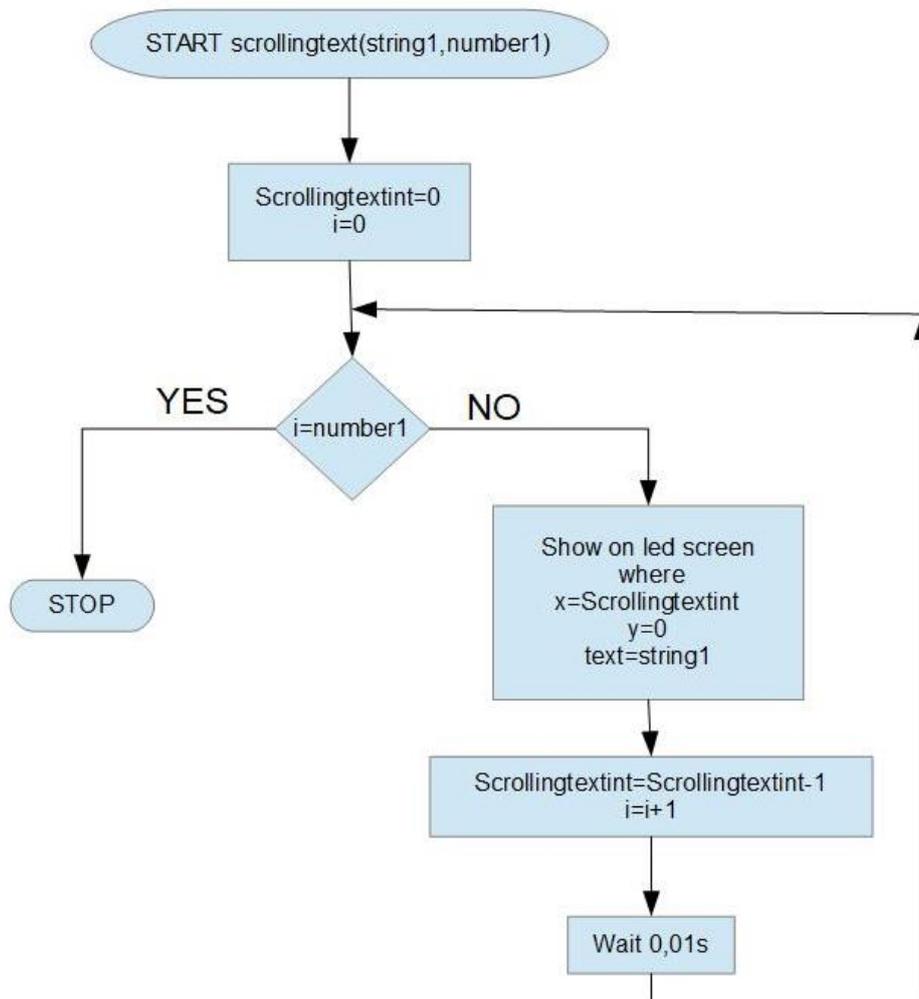
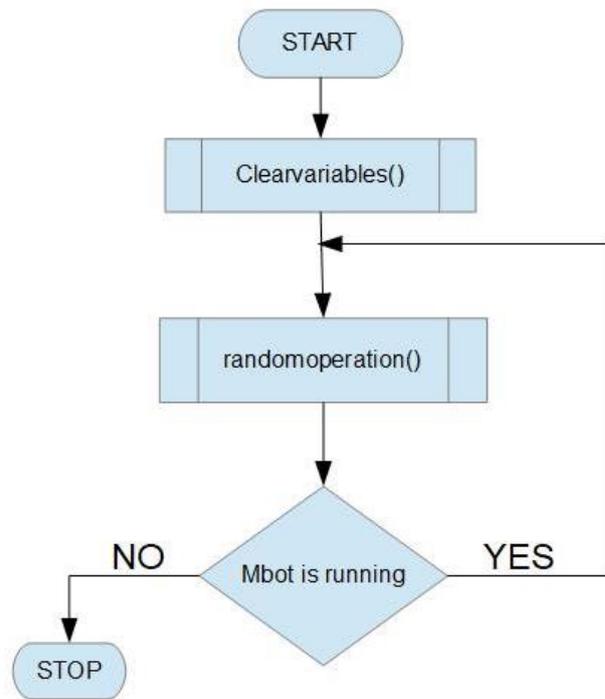


Second Version









STUDENT'S EVALUATION

After the activity student who built the robot:

- ❖ Use variable.
- ❖ Can make block (the function with parameter).
- ❖ Can use round instruction.
- ❖ Devide program to smaller function.

This robot can be used to practise math operation on different level of education.

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Página web Scratch en español. (<https://scratch.mit.edu>)

“Jugando con MBlock”. Makeblock España

“Divirtiéndome con MBot”. Susana Oubiña

Comunidad de Makeblock en español. (<http://www.makeblock.es/foro/>)

MORE INFORMATION

DIFFICULTIES:

- MOTORS FOLLOWING A STRAIGHT LINE: when executing the order “move forward”, robots tend to divert slightly to the left side. In order to correct it, it is advisable to set M1 (left motor) to a 255 speed and M2 (right motor) to a 245 speed.
- ARBITRARY PARAMETERS STABLISHMENT: when the second degree equations are created, “a” value cannot be “0” and the square root solution cannot be negative, since the result will not exist. The programme will have to find arbitrary parameters until these conditions are accomplished.
- ROUNDING: the “round” block rounds the solution to a whole number. In order to get two decimals it is necessary to multiply the result per 100, and afterwards to round that number divided by 100.

