Blue Bot Project Experiment

Julian Alvarez, Katell Bellegarde, Jean-Jacques Flahaut, Thierry Lafouge

Blue Bot Project experiment

First statistical results of the performance of 5-year-olds pupils on their ability to program

Julian Alvarez

Devisu – Université Polytechniques Hauts-de-France, ESPE - Lille Nord de France, Ludoscience, France

Katell Bellegarde

CIREL – Université de Lille, ESPE – Lille Nord de France, France,

Jean-Jacques Flahaut

ESPE - Lille Nord de France, France

Thierry Lafouge

ELICO – Université Lyon 1, France

Abstract

This paper presents preliminary statistical results of the "Blue Bot research" conducted in 2017. It is a comparative study dedicated to introduce robotics and computer science to children of 5 years old, in their final year at kindergarten. The experiment was carried out in 35 classrooms from Hauts-de-France (North of France). The serious gaming activity proposed three different modalities: the body, the robot and digital tablet. We will present the first results of the various pre- and post-test studies carried out during the experimentation.

Keywords: Serious Game, Toy, Game, Serious gaming, Robot, Pedagogy, Comparative study, kindergarten, Experiment, Coding

Serious digital games are attractive educational tools and resources which are undoubtedly relevant in appropriate contexts and situations (Alvarez et al., 2016). Faced with growing screen consumption by young children and its dangers on the development of several capacities, the exposure of kindergarten children is questionable (Tisseron, 2013). In order to benefit from the potential of serious digital games, without achieving overexposure to the screen, the use of robotic toys like Blue Bot seem relevant. For forty years, robotics has been the subject of interesting applications in the field of education. This educational trend called "educational robotics" (Papert, 1981) is aimed at the public (from kindergarten to adult education) with a goal of initiation into robotics and computer science. Its playful aspects and tangible interfaces favour an early understanding of the concepts of robotics and programming (Komis, Misirli, 2013). However, serious digital game terminals offer advantages in terms of cost (often free, like the online game robot Blue Bot) and dissemination within the school context.

This paper presents preliminary results of the "Blue Bot research" which was conducted in 2017. It is a comparative study dedicated to introduce robotics and computer science to children in their final kindergarten year. The experiment was carried out in 35 classrooms from Hauts-de-France. The serious gaming activity proposed three different modalities: the body (Greff, 2004), the robot and digital tablet. We will present the results of the various pre- and post-test studies carried out during the experimentation with a statistical approach. At this stage, the primary idea is therefore to explore the validity of the implemented methodology in order to let us continue, or not, the data analysis.

Experiment description

The pedagogical use of various supports intended to lead the learning of coding (formulation of the kindergarten's program) and programming (to recognize instructions, to arrange them, to develop a program, to achieve a determined displacement) is the heart of the Blue Bot Project research study. More precisely, this research project proposes to evaluate the contributions of robotics and digital technology in the acquisition of sequential programming by 5 year old students. These students are in the last year of French kindergarten, named "Grande Section Maternelle" (GSM).

The central hypothesis of the Blue Bot Project is the following: *"Robotics by its tangible dimension, fun and "out of the body" facilitates cognitive mediation in the acquisition of sequential programming among pupils of Grande Section Maternelle (GSM)."*

Presentation of the Blue Bot Project' Serious Game

In the scope of the Blue Bot project, the set of activities proposed, is based on a serious game whose main character is the Blue Bot robotic toy. The principle of the game is to propose a navigational course consisting of a start and finish line. Concretely, it is about introducing pupils to robotics / computer science by using a serious game which is defined by three different modalities:

- use of the robot: the children program the Blue Bot robot which moves on a checkerboard, which was printed on a plastic carpet and placed on a table.
- use of a tablet: the game is replicated in a virtual environment and played on a digital tablet.
- use of the body: a child embodies the robot and moves on a chequered floor. Other children advise what to do according to a set of instructions.

Whatever the modality, the principle of the serious game is always the same: to code Blue Bot in order to move it in the checkerboard and make it reach the finish point (illustrated by a schoolbag or a friend robot). Blue Bot always starts from a departure point (symbolized by a house) (cf. Figure 1a) and moves from level to level, and a sequence is proposed: The courses offer obstacles to avoid, for example, a nasty dog (cf. Figure 1b).

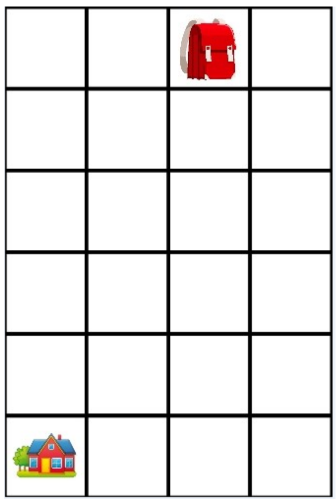


Figure 1a: Level 1 proposed for learning activity in the Blue Bot Project experiment

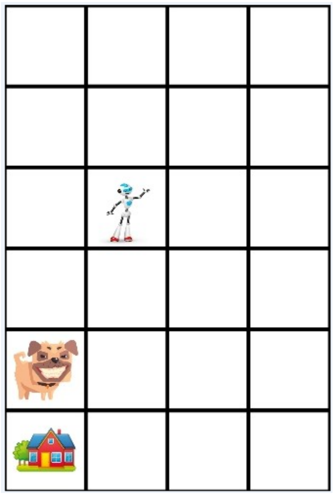


Figure 1b: Level 5 proposed for learning activity in the Blue Bot Project experiment

Learning activities:

To prepare the pupils to play the different versions of the serious game, different learning activities are proposed:

* **Preliminary activities** carried out prior to the programming work.

- Activity of locating, in the space with the body, as per the teacher's usual lesson scheme. Preparatory / recall activity.
- Learn a nursery rhyme "the robot" to help understand the different modes of movement.
- Reading a part of *Vibot* story (Romero, 2016, pp. 1-15): an activity of enlistment which piques the interest of the child, to make him/her interested in the programming activities which follow. The robot is the central character of all the experiments regardless of the type of cognitive mediation.

* **1st step: introduction to algorithmic and programming instructions** – for handling the robot, the tablet, the checkerboard and the functions of the various dashboards (on the robot, tablet, and the body, through management pictograms)

* **2nd step: progressive introduction, step by step, of the different commands** of the Blue Bot robot (whatever the modality – body, robot or tablet)

* **3rd step: creation of a coding sequence** using a system of rules for each type of situation teaching / learning – locational problem proposed by the teacher: to drive the robot to a specific place.

* **4th step: creation of a coding sequence using rules with additional constraints** (fixed obstacle, path to follow, etc.) – locational problems proposed by the teacher according to these constraints.

Due to the limited availability of robots and digital tablets, a four week rotation was scheduled to lend them to all the 35 classrooms participating to the experiment. Thus, during 16 weeks (4x4 weeks), all the 35 classes were able to access robots and tablets as detailed in the Table #1 below:

Classroom group / Material	A (11 classrooms)	B (11 classrooms)	C (13 classrooms)
Weeks 1 to 4	robot	tablet	-
Weeks 5 to 8	tablet	robot	-
Weeks 9 to 12	-	-	Robot
Weeks 13 to 16	-	-	Tablet

Table #1: Loan rotation of the material for the Blue Bot Project experiment

These rotations made it possible to expose the different classrooms to the 3 different modalities (Robot, Tablet, Body) at different times and sequences which were exploited as part of the experimental protocol. This protocol promoted the study of three dimensions:

Dimension #1: pupils' assessment of teaching / learning situations according to the use, or not, of robotics and digital technology.

Dimension #2: assessment of pupils’ performance in programming based on pre-tests and post-tests.

Dimension #3: pupils’ cognitive acquisitions.

In the scope of this paper, we focused only on the experimental part related to the Dimension #2 (Pupils’ performance).

Dimension #2 experiment description

To explore Dimension #2 of the Blue Bot experiment, the proposed methodology was a pre-test and post-test study. These were scheduled around the educational activities just described. By exploiting the loan turnover of robots and tablets (see Table #1) and positioning post-test phases at different stages, seven different combinations of modalities were obtained: #1 Body alone (B), #2 Robot alone (R),

#3 Tablet alone (T), #4 Body + Robot (BT), #5 Body + Tablet (BT), #6 Robot + Tablet (RT) and #7 Body + Robot + Tablet (BRT). The Table #2 presents these combinations.

B (4 classrooms)	R (4 classrooms)	T (4 classrooms)	BR (4 classrooms)	BT (4 classrooms)	RT (4 classrooms)	BRT (4 classrooms)	P (7 classrooms)
pre-test	pre-test	pre-test	pre-test	pre-test	pre-test	pre-test	pre-test
Body	robot	tablet	body	body	robot	body	-
post-test	post-test	post-test	robot	tablet	tablet	robot	-
Robot	tablet	body	post-test	post-test	post-test	tablet	-
Tablet	body	robot	robot	tablet	body	post-test	post-test

Table #2: Presentation of the different group of the Blue Bot project experiment

An eighth group named P (for Placebo) was composed to perform only a pre-test and post-test evaluation without any intermediate learning activity. This was to check whether the learning activities play a significant role in the other seven groups (B, R, T, BR, BT, RT and BRT).

Pre-tests and post-tests description

The pre-tests and post-tests activities were proposed to evaluate the pupils' performance and were structured in 3 parts:

Activity # 1 – Decoding: to decode a set of 10 instructions by drawing a moving path on a grid of 24 squares (4x6). In real terms, the children must read the different instructions represented as three kinds of vectors (go forward, turn left, turn right) and reproduce, on the grid, the path that Blue bot must take (cf. Figure #2).

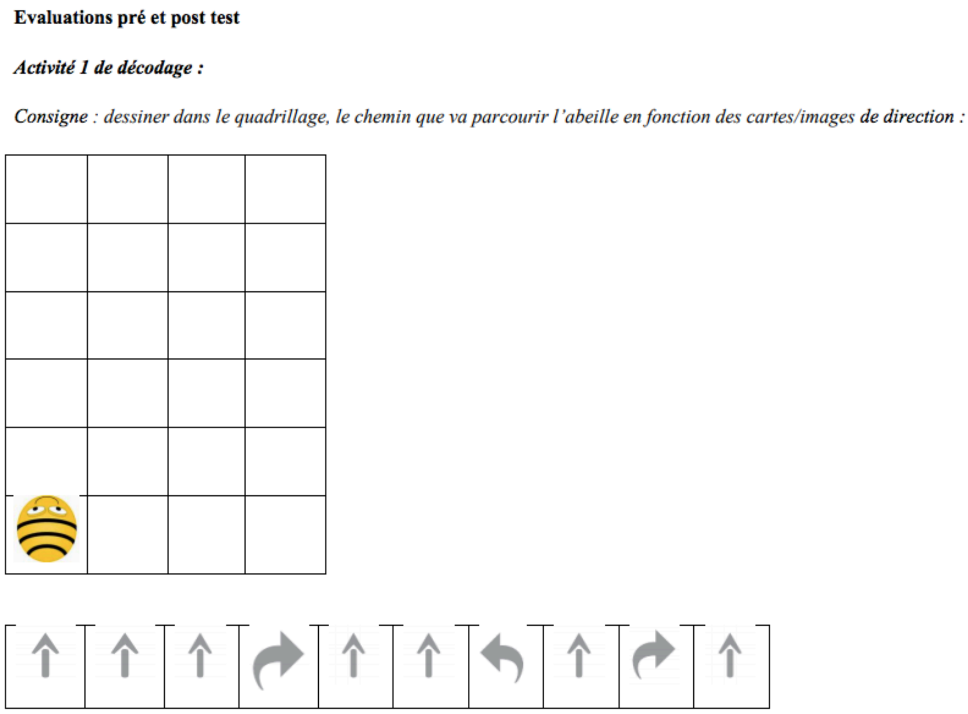


Figure #2: Decoding activity

Activity # 2 – coding: to code the Blue Bot's course according to an existing path. Specifically, the children must deduce and transcribe the list of different instructions to be represented as arrows from a proposed path pattern (cf. Figure #3).

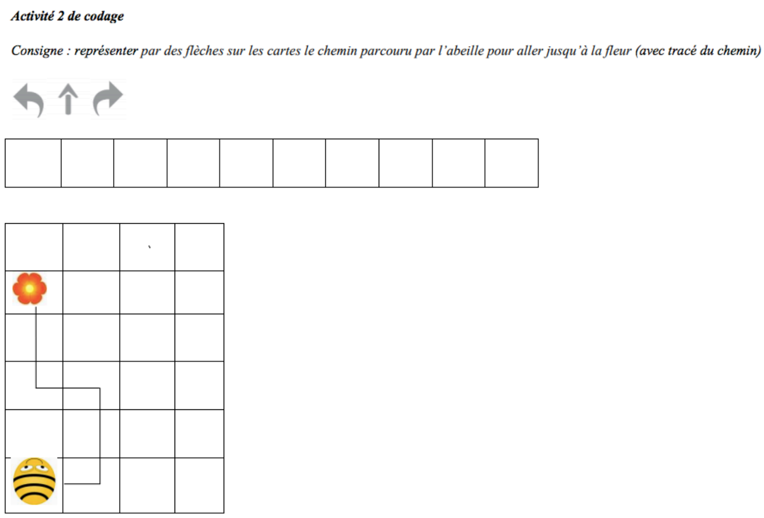


Figure #3: Coding activity

Activity # 3 – design: to firstly, propose a path taking into account the different constraints (elements to join and another to avoid) and secondly, the associated coding. Specifically, the children have to first propose the course of the Blue Bot robot, in the form of a path drawn on the grid, and then compile the arrow instruction lists. To draw the path, the children must take into account the necessity to pass through two flowers and avoid a bird (cf. Figure #4). Note that there are two possible paths, the most optimized needs seven instructions, the other less optimized, needs 9.

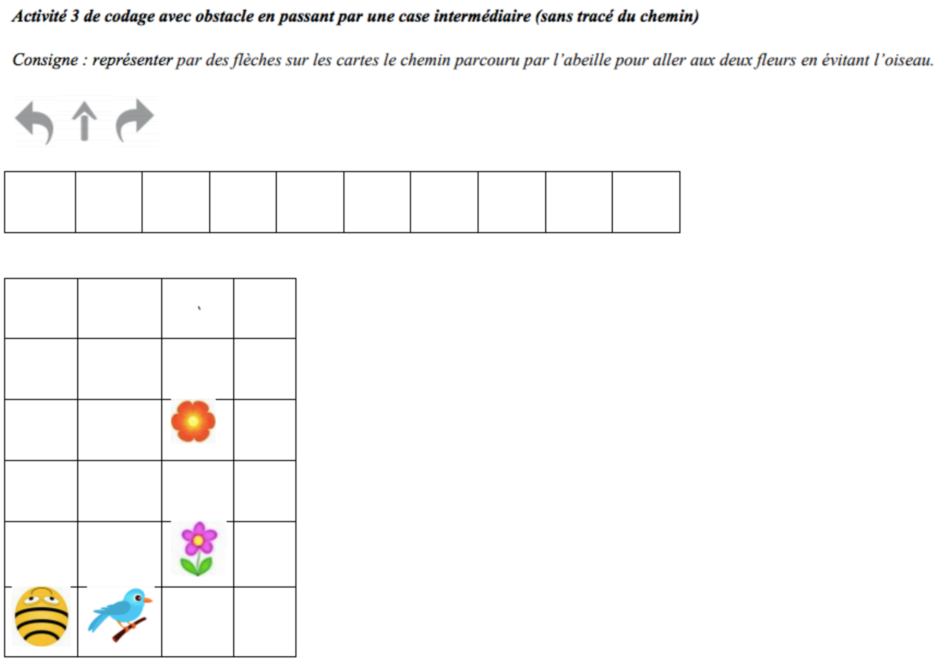


Figure #4: Design activity

The various pre-tests and post-tests were then sent by the teachers, without any assessment, to the researchers. This last one having established a list of twenty-eight evaluative variables and proceeded to the corrections by themselves to ensure homogeneity in their treatment. Asking the different teachers to assess would probably have given rise to multiple evaluative approaches, and therefore data difficult to examine. Once all these assessments had been made, a statistical treatment was performed on all the data.

Results

A quick statistical treatment of the experimental data

Within the scope of this paper, 3 of the 28 variables identified were used in statistical data processing. These 3 variables focused on the analysis of the children's performance for the 3 activities determined by the post-test level.

The 3 variables are:
- for the Decoding activity: reaching the final expected square, coded by Yes/No.
- for the Coding activity: reaching the final expected square, coded by Yes/No.
- for the activity of Conception: number of flowers reached (0, 1 or 2), coded by 0-Point, 1-Point, 2-Points.

The unanswered are coded by "Wr" ("*Without reply*").

With these 3 variables, the first question to evaluate is whether the Placebo group (P) differs significantly from the others. That is to say, if the experiment differentiates students following learning activities from those of the P group (witness pupils).
Secondly,the different groups were ranked according to performance.

It should be noted that out of the 8 groups listed in Table 2, only 6 were analyzed. These are B (Body), R (Robot), T (Tablet), RT (Robot + Tablet), CRT (Body + Robot + Tablet), and P (Placebo).) For BR (Body + Robot) and BT (Body + Tablet) groups, no data could be collected due to problems related to the implementation of the experimental protocol.

According French words, the 6 remaining membership groups are coded as follows:
Group Body => « C » (« *Corps* » in French),
Group Robot => « R » (same word in French),
Group Tablet => « T » (« *Tablette* » in French**),**
Group Body + Robot => « CR »
Group Robot + Tablet => « RT »
Group Body + Robot + Tablet => « CRT » (« *Corps* + *Robot* + *Tablette* » in French)
Group P => « P » (« *Placebo* » in French).

The sample concerned consisted of 230 children who were randomly assigned to the 6 groups mentioned. We use qualitative variable crossover techniques as well as the test of χ^2. Crossed data is presented in Table #3.

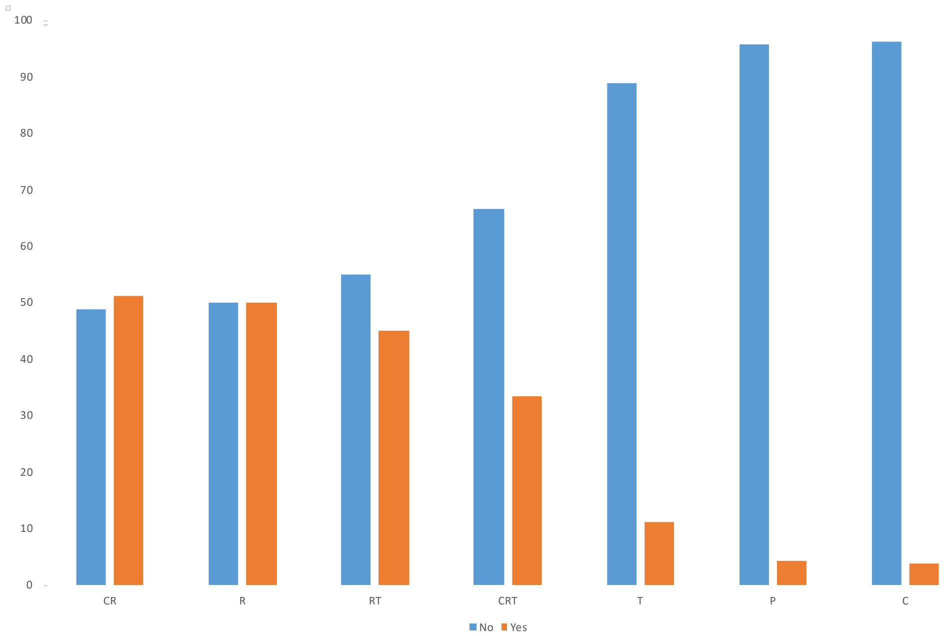
	No	Yes	Total		No	Yes	Wr	Total		0 Point	1 Point	2 Points	Wr	Total
C	25	1	26	**C**	24	2		26	**C**	14	7	5		26
CR	22	23	45	**CR**	34	11		45	**CR**	8	12	24	1	45
CRT	4	2	6	**CRT**	6			6	**CRT**	4	1	1		6
P	45	2	47	**P**	35		12	47	**P**	26	18	2	1	47
R	14	14	28	**R**	25	3		28	**R**	11	6	11		28
RT	33	27	60	**RT**	51	6	3	60	**RT**	20	20	19	1	60
T	16	2	18	**T**	17	1		18	**T**	10	8			18
Total	159	71	230	Total	192	23	15	230	Total	93	72	62	3	230

Table #3: Crossed data for Decoding (Tab. 1), Coding (Tab. 2) & Design (Tab. 3) activities

Variable Decoding and Coding

We cross the variables, belonging to a group with the Decoding variable and analyze this cross-tab (cf. Table #3 – "Tableau 1 Décodage"). We found that 31% of children passed the decoding post-test.
Then a new group was created (C + R + T + CR + RT + CRT) made up of all the children involved in the experiment. That represents 80% of our sample. At this stage, a table was obtained which crosses two variables, belonging to a control group (Yes / No), reaching the final expected square (Yes / No).

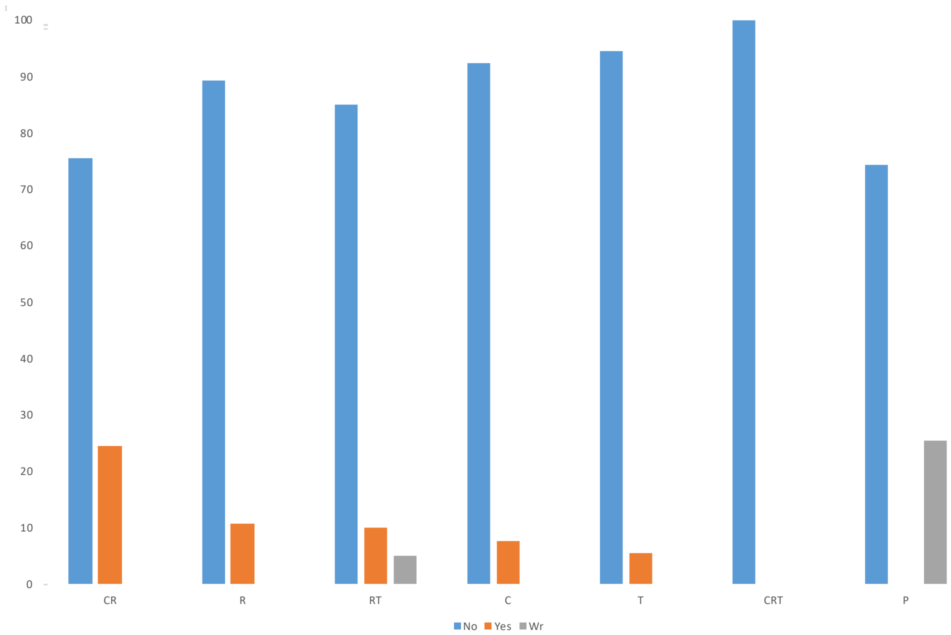
The χ^2 calculation of the crosstab gives 19.6. We then concluded that there was a significant statistical dependence (the χ^2 read in the table is 3.84 for a risk of 5% and a dof (degrees of freedom) of 1) between the success at the Decoding post-test and the placebo group membership.
In the second phase, in order to classify the different groups according to the performances, the percentages of the score of each group was calculated of those which achieved, or not, the final expected square. The result is presented by graph #1, where the groups are ranked by decreasing performance.



Graph #1: Ranking of Decoding groups

The Placebo group « P » and the Body group « C » are the worst performer with 96% failure rate, the Body + Robot « CR » group came first with 51% success.

We use the same method for the Coding variable. Only 10% of the children passed the post-test (cf. Table #3 – "Tableau 2 Codage"). The calculation of χ^2 is 6.56. We then concluded that there was a significant statistical dependence. The dependency link was nevertheless weaker than for the Decoding variable. In order to rank the different groups according to the performance, we calculated the percentages for each group which reached the final expected square. The result was presented by graph #2, where the groups were ranked by decreasing performance.

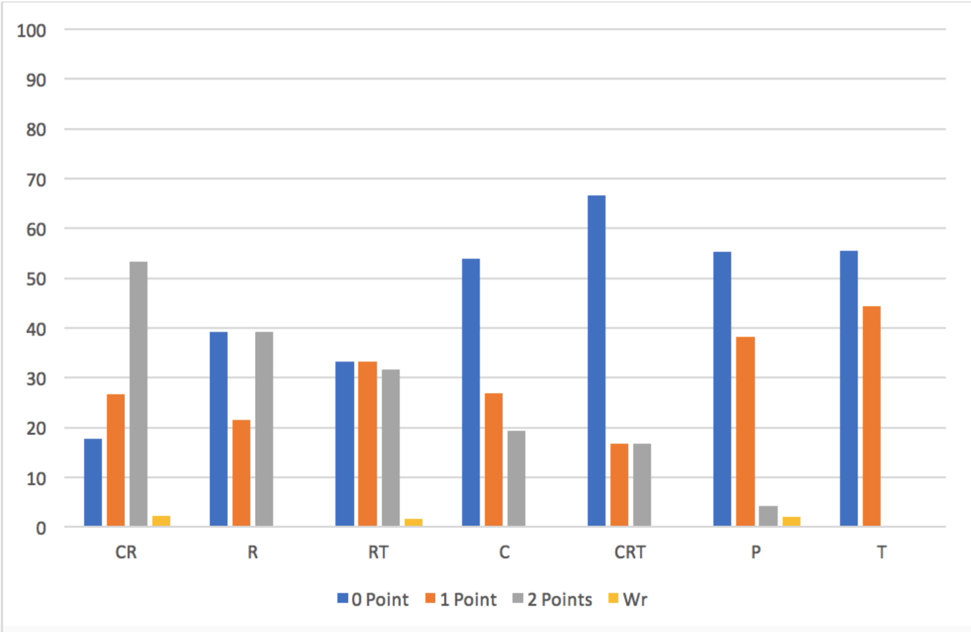


Graph #2: Ranking of Coding groups

At least 80% of the pupils in each group failed this test. The results are less differentiated and exploitable than previously. The best performing group was the Body + Robot « CR » group with 24% success. If the failures and unanswered results were summed, the CRT group and the P group both achieved 100% failure.

Design variable

We cross the group variable and the Design variable. 27% of the pupils reached two flowers (cf. Table #3 – "Tableau 3 Conception"). We calculated, as previously, the percentages lines of the crossed table. The data was then ranked by decreasing performance, which was the percentage of flowers attained twice (see graph #3 below).



Graph #3: Ranking of Design groups

53% of the Body + Robot group « CR » achieved two flowers while only 4% of the Placebo group « P » passed this test. Note, however, that the T group has a lower performance than P group.

Conclusion

After presenting the Blue Bot project and its experimental protocol, aimedat studying, in particular the performances of 5-year-old children to program a robot toy, we conducted initial statistical analyzes on 3 of 28 defined variables focus on the post-test part.

Preliminary results show that post-tests differ in their difficulty. « CR » (Body + Robot) group in 3 post-tests out of 3, is the most successful, followed by the R (Robot) group and « RT » (Robot + Tablet) in the third position. The « P » group (Placebo) represents the lowest Coding achievement. For the Decoding and Design activities, « P » group is in the penultimate position. This shows that the educational activities and serious games proposed to pupils had an effect in learning. In this first analysis, apart from the P group, the modalities which had the worst performance were Tablet « T » , Body « C » and Body + Robot + Tablet « CRT» in 1 activitiy out of 3.

The fact that the three associated modalities CRT represent results less efficient than R (Robot only) group, raises questions to pursue in further studies. A multi-dimensional statistical analysis should be carried out, in order to visualize the positioning of the groups on the three study axes which are; Decoding, Coding and Design by measuring the diachronic effect of the experiment.

However, waiting to do that, at this stage, based on the statistical test of χ^2, we are able to say that the Blue Bot Project experiment validates the implemented methodology, and we can thus continue to analyze the data collected.

Aknowledgments

Thank you for their advice, expertise, sharing experiences, supports and suggestions: Gilles Brougère, Serge Tisseron, Sylvie Leleu-Merviel, Dorothée Hallier-Vanuxemm, Margarida Romero, Jean-François Condette, Alfonsino Cutillo, Romain Deledicq, Jean-Jacques Flahaut, Vincent Hurez, Thierry Lafouge, Yoann Lebrun, Philippe Leclercq, David Detève, Angelino Mascaro, Patrick Pelayo and Gilles Petit and all the partners associated with the Blue Bot research project: the Lille Dane, ID6, the Digital Greenhouse, the academies of Lille and Dijon, the DeVisu Research Laboratory of the Polytechnique University Hauts-de-France France and ESPE Nord-de-France and the University of Laval.

References

ALVAREZ, J., & CHAUMETTE, P. (2017): Présentation d'un modèle dédié à l'évaluation d'activités ludopédagogiques et retours d'expériences. *Recherche et Pratiques Pedagogiques En Langues de Specialite - Cahiers de l'APLIUT.*, https://journals.openedition.org/apliut/5659

GREFF JP. (2004): Le corps d'abord! *Education enfantine*, n°1056, pp. 62-63.

KOMIS V., & MISIRLI A. (2013) : Etude des processus de construction d'algorithmes et de programmation par les petits enfants à l'aide de jouets programmables. In G-L. BARON, E. Bruillard, & V. KOMIS . *Sciences et technologies de l'information et de la communication en milieu éducatif*. Clermont-Ferrand, edutice.pp. 271-281

LINARD M. (1996): *Des machines et des hommes. Apprendre avec les nouvelles technologies.* Paris: L'Harmattan.

PAPERT S. (1981): *Jaillissement de l'esprit. Ordinateur et apprentissage*. Paris: Flammarion

ROMERO M (2016): *Vibot the Robot*. (n.d.). Loufane

ROMERO M., USART, M., & OTT, M. (2015): Can serious games contribute to developing and sustaining 21st century skills? *Games and Culture, 10*(2), pp. 148–177.

TISSERON S. (2013): *3-6-9-12 Apprivoiser les écrans et grandir*. Toulouse, Erès.