OPPORTUNITIES OF GAME OF GO FOR MATHEMATICS LEARNING AND TEACHER TRAINING

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Abstract

We present a classroom research developing resources to teach mathematics in French primary school by using the game of Go. Go players, teachers, searcher meet at university to produce teaching resources, to implement them in the classroom and to have a reflective phase to evaluate and improve the resources. Through the representation register of the game of Go, different mathematical domains can be investigated: number, geometry, magnitudes, logic, algorithmic. To analyse the resources and the practices we propose the theoretical frameworks of anthropological theory of didactic. Didactic engineering enables to reflect on the training piloted in the research group.

Keywords: game of Go – resources - in service training - France

Aim of the research

Medal Fields Villani supervised a report on mathematics teaching (Villani & al. 2018, p.15) claiming " the pleasure of game : In order not to allow anxiety about the mathematical school". Poirier & al (2009) showed the relation between game and mathematics learning at primary school. Research has shown the interest of strategy games in mathematic teaching **(**Movshovitz-Hadar 2011). Among these strategy games Jancarik (2017) has shown "the areas that are developed through chess are primarily problem-solving power but also logical thinking and ability to visualize in geometry" (Ibidem. p.226). Research in primary school has shown that the game of Go, another strategy game, develops the cognitive functions (Tachibana & al. 2012). The aim of this classroom research is to study the opportunities of the game of Go to learn mathematics and to propose a teacher training course to implement the game of Go in French primary school in accordance with the French syllabus.

Theoretical framework

Using the terminology of Chevallard's anthropological theory of didactics (Bosch & al. 2006) we consider that the Strasbourg Go Club (Strasgo 2019) is an institution that produces the knowledge of the ways to play the Go game. French primary school is another institution where the mathematical syllabus is taught. We study the double transposition of the knowledge of Go Game and of

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the knowledge of mathematical syllabus in the French primary school. We study different teaching tasks offered in classes, the way of doing this task and how this way of doing is justified, here from the point of view of the game of Go and from the mathematical point of view. We use the problems offered by the game of Go as a new approach to learn mathematics because we assume that in this context "pleasure, elation and satisfaction occur" (Debellis & al. 2006, p.134). Furthermore the material used in Go game (board and stones) enables to work in a new register of representations. "Mathematical comprehension begins when coordination of registers starts up. […] Mathematical thinking processes depend on a cognitive synergy of registers of representation" (Duval 2006, p.126). We assume that the context of the game of Go will help to learn mathematics.

Methodology used

This research takes place in an IREM (Research Institute on Mathematics Teaching): "Independent from, but close to mathematics departments, these university structures welcome university mathematicians, teachers, teacher educators, didacticians and historians of mathematics who collaboratively work part-time in thematic groups, developing action-research, teacher training sessions based on their activities and producing material for teaching and teacher education" (Artigue & al. p.13).We use the methodology of didactic engineering: "a phase of preliminary analysis and design, a phase of teaching experiments, and a phase of retrospective analysis" (Ibid. p.901). One time a month the research group meet with the following phases: playing and learning Go game, reporting about the experiments in the classes and sharing produced resources, reflecting on the experiments and and conceiving new experiments to implement before the next meeting. To analyse the teaching experiment we use the double approach methodology (Robert & al. 2005): "This method proposes a twofold approach: on the one hand – in a didactics-centred approach – we developed a general frame-work for analyzing teachers' practices taking into account two elements that are very closely linked, students' activities and the teacher's management of the class, [...]; and on the other hand – in a cognitive ergonomics approach – we have considered the teacher as a professional who is performing a specific job" (Ibidem p.270).

Examples of details of the experiment

Short presentation of the game

First let us introduce shortly to Go game. It is a strategy game for two players, one player has the black stones and the other one the white ones. One player takes turn to place one stone on a vacant point of intersection of the board. The

stones are not moved. This player captures a stone or group of stones of the other colour when they are surrounded by player's stones on all orthogonally adjacent points. At the end of the game, the winner is the player who have the greatest number of stones on the board. We adopted the variations of the rule of the Game proposed by Strasbourg Go Club (Strasgo 2019).

The research group

The research group gathers varied members: an university mathematician (former searcher in pure mathematics and at the present time searcher in mathematics didactic), a post-secondary mathematics teacher member of Strasbourg Go club, a secondary school teacher captain of the French Go Game team, and about 10 primary schools teachers (with classes from grade 1 to 5 represented). Some teachers have no experience about Go game. Some teachers didn't follow mathematics initial studies. Some teachers have a Go game experience, in a club outside the classroom and the compulsory courses. They notice the pupils' motivation to play because the rule of the game are easy to understand. Some pupils who know languages difficulties (because French is not their mother language) find easier to express themselves during the game.

Learning of Go game knowledge

They are different rules of the Game. And Strasbourg rules (Strasgo 2019) are easy to understand and well adapted to a gradual introduction from primary school. In the first meeting of the research group different rules are introduced: the winner has the greatest number of stones on the board. The discussion is how the pupils compare the two number of stones. The second rule is the capturing of stones surrounded by stones of the other color. Here different exercices are proposed: to complete a board to surround 1 stone, 2 stones …, to recognize a surrounded territory, to go on a play to surround stones (figure 2). Another temporary rule is to consider that game is over when a player has captured in the whole 5 stones and at this step the players compare the stones kept on the board. This rule could change later when players are sufficiently familiar with the play. In the next meeting of research group, other rules will be learned in this teacher training to be transposed in the classroom activity.

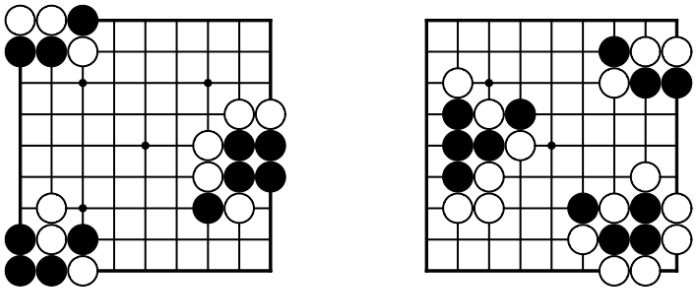

Figure 1: To recognize a surrounded territory

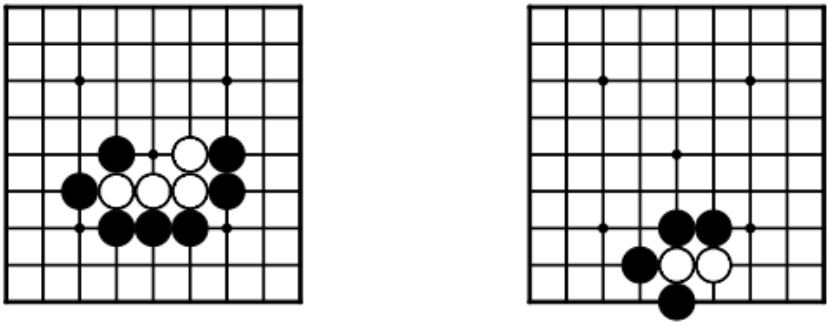

Figure 2: Black is playing and captures white stones in 2 turns

Learning of mathematical knowledge

Counting procedures are proposed, by grouping of stones in rectangles or lines without necessity of counting (figure 3) or by enumerating.

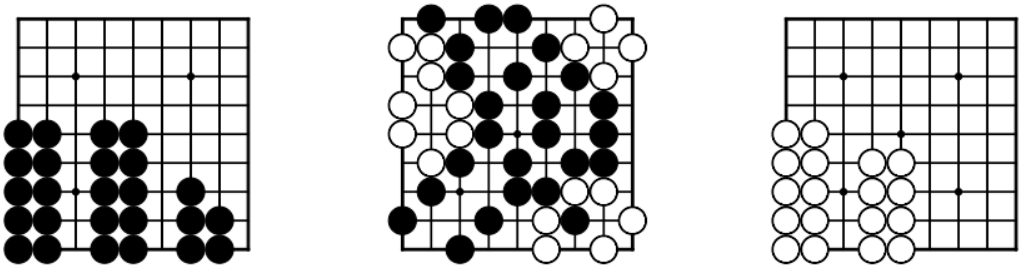

Figure 3: comparing the numbers of stones without counting

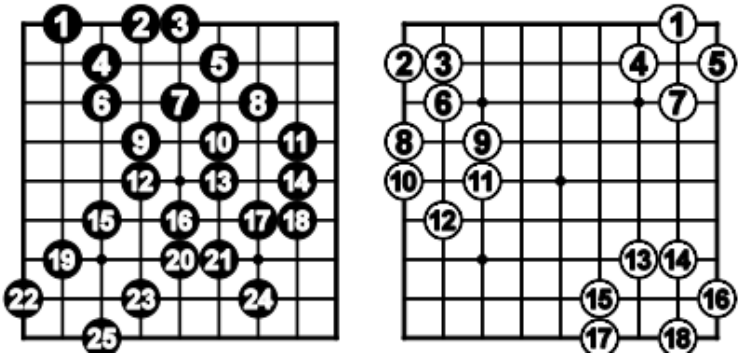

Figure 4: counting the stones by enumerating

Grouping the stones can offer **representation registers** (Duval 2006) for different mathematical notions. Grouping in lines of same length can be a representation register of multiplication understood as the iteration of an addition (for example 20=5+5+5+5). Grouping in rectangle can be a representation register of multiplication understood as the product of two magnitudes (for example 20=5x4). Grouping in 2 lines of 5 stones or in 1 line of 10 stones can be a representation register of decimal number system.

Geometry (figure 5) can be worked with lines (are the stones forming a straight line?), the surrounded territory (border, area) with measurement of magnitudes with stones.

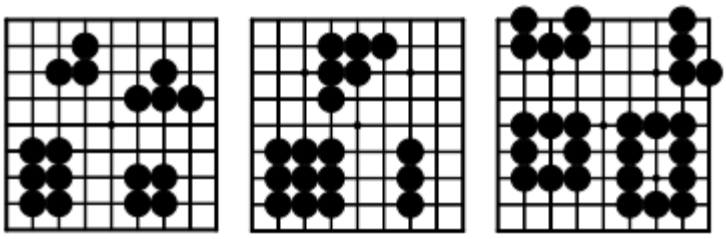

Figure 5: Form recognizing: lines, triangle, square ...

Other domains can be worked: reasoning with game strategies, plane coordinates on the Go board, data organization with the results of a Go game tournament ...

Feedback of teaching experiments

Experiments show that different parts of the syllabus are worked, for example in grade 1, addition (complement to make 10) or lines (horizontal, vertical, diagonal). Pupils seem to easier represent the notion in the Go context that looks familiar.

Some teachers consider general benefits of Go game. The moral rule is important: do not cheat at play. The pupils skilful with Go game are not always those who are skilful in mathematics. Pupils play each other at the Go game and are used to partner's change. The social life of the class is improved.

Two modalities of work: a couple of pupils play with the Go game or a collective discussion by using the classroom board (figures 6 and 7). To work the situations at the classroom board helps a lot the pupils with difficulties. The difficulties can be on Go game side to understand the rule or on mathematical side to understand a mathematical idea.

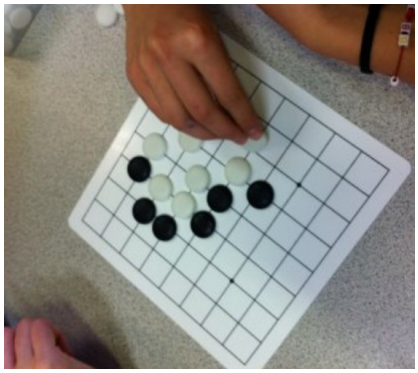

Figure 6: Players' couple

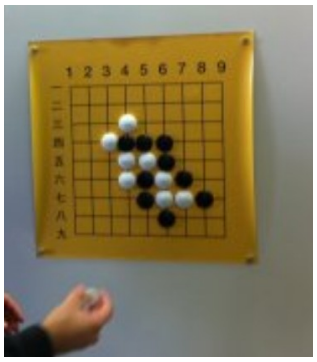

Figure 7: Discussion at the classroom board

A teacher has worked algorithmic and

programming (a part of French syllabus at primary school) by working Go situations with Scratch programming language (Figure 8).

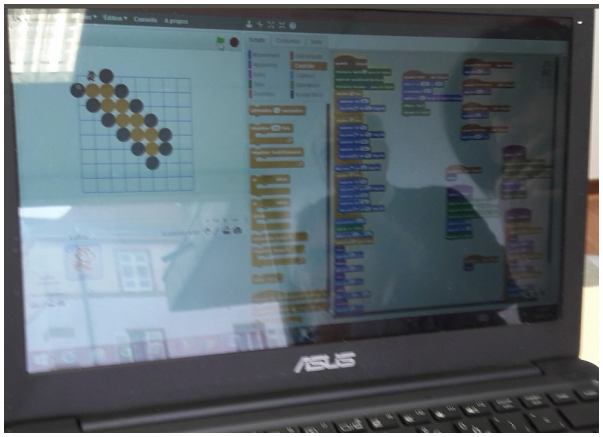

Figure 8: Go game with Scratch

Sharing of materials and resources

A teacher adapted the counting stick (Millet & al. 2007, p. 138) to learn multiplication table with labels representing the numbers with rectangle of Go game stones (Figure 9).

Figure 9: Labels with Go stones representation for multiplication table of 3

A software (Strasgo 2019) is available and enables to train individually on a computer (Figure 10).

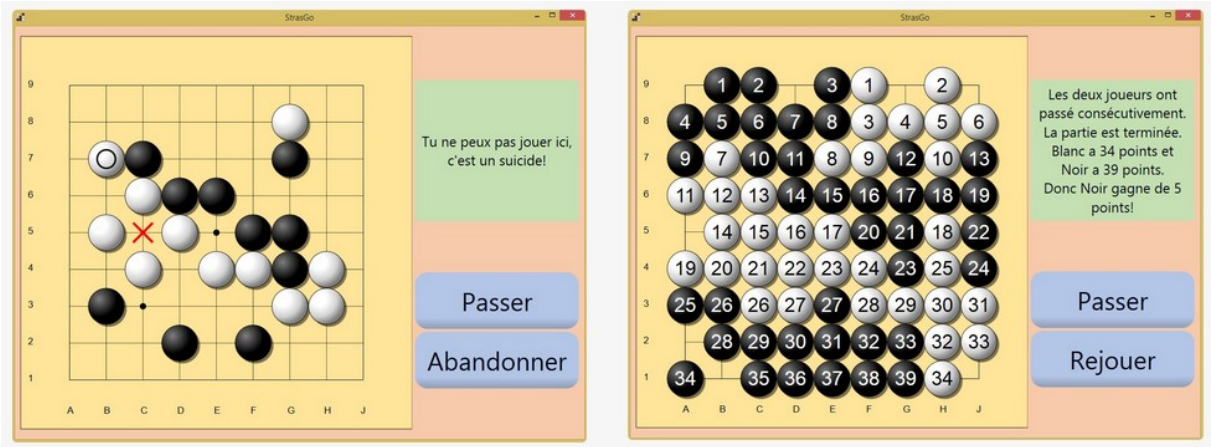

Figure 10: A Go game software to train individually

Some teachers uses video on Dragon or Manga stories to motivate pupils and bring cultural context.

Results and conclusions for teaching ansd teacher training

With the first experiments it is possible to move the Go game from voluntary activities outside the classroom to compulsory activities inside the classroom. **For the Go game knowledge**, the experiments show that is possible to learn adapted Go game rules and to play Go game in primary school. The progression proposed to learn the rule of Go game have been well adapted to the variety of class situations. From the pupils‘ point of view the experiments show that motivation, pleasure, social behaviour are developed through Go game activities. **For the mathematical knowledge** many parts of the French syllabus of primary school can be taught through the use of Go game. The Go game brings interesting registers of representation and the change of registers is a good way to understand the concepts and the procedures.

For most of the teachers and the pupils, it was a first encounter with the Go game. Next year familiarity and confidence will help the teaching and the learning. The evaluation of the experiments has to become more precise. The group is developing resources and new situations fitting with the syllabus. This research project is until now in an exploration phase with a qualitative evaluation. The evaluation should better specify the skills developed and the criteria to be observed to verify the development of these skills. It would be interesting to have control group that do not use the Go game and to observe if there are significant differences for some evaluations. However, it remains difficult to neutralize some variables; for example, when a teacher teaches mathematics through Go game in a class he has in charge the all year long, it is not possible for him to teach another class in the same year without using the Go game. If we make the comparison with the class of another teacher, there is a teacher variable that can change the comparison. Here we see one of the difficulties of action research, which remains essentially a research with qualitative experiments.

References

Artigue M. & al. (2019). The French Didactic Tradition in Mathematics. In Blum W. & al. (Eds.) *European Traditions in Didactics of Mathematics.* Springer. ICME-13 Monographs.

Bosch,M., Gascon, J. (2006). 25 years of didactic transposition. ICMI Bulletin, 58, 51–65 .

Debellis, V., & Goldin, G. (2006). Affect and Meta-Affect in Mathematical Problem Solving: A Representational Perspective. *Educational Studies in Mathematics, 63*(2), 131-147.

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics (2006) 61: 103–13.*

Jancarik Antonin (2017) The potential of the chess environment in mathematics education – pre-service teachers' perspective. *In J. Novotna, & H. Moraova (Eds.), International SymposiumElementary Maths Teaching. SEMT'17.* Proceedings, 225-235. Prague : Charles University, Faculty of Education.

Margolinas, C. & al. (Ed.). (2013). Task Design in Mathematics Education. *Proceedings of ICMI Study 22 (Vol. 1).* Oxford.

Margolinas, C., Drijvers, P. (2015). Didactical engineering in France; an insider's and an outsider's view on its foundations, its practice and its impact. *ZDM Mathematics Education (*2015) 47: 893–903.

Millett, A., Brown, M., Askew, M. (2007) Primary Mathematics and the Developing Professional. Springer.

Movshovitz-Hadar, N. (2011). Bridging between mathematics and education courses: Strategy games as generators of problem solving tasks. In *O. Zaslavsky & P. Sullivan (Eds.), Constructing knowledge for teaching secondary mathematics: Tasks to enhance prospective and practicing teacher learning*, 117-140, Springer.

Poirier, L., Novotna, J., Godmaire, C. (2009). Games and learning mathematics. In J. Novotná, H. Moraová (Eds.), International Symposium Elementary Mathematics Teaching SEMT'09 (pp. 277–278). Prague: Charles University, Faculty of Education.

Robert, A., Rogalski, J. (2005). A Cross-analysis of the mathematics teacher's activity. an example in a French 10th-grade class. Educational Studies in Mathematics, 59: 269–298

Strasgo (2019, March 28) An application brought to you by the Strasbourg Go Club to discover the game of Go. Retrieved from http://strasgo.gostrasbourg.fr/index_en.html .

Tachibana Y, Yoshida J, Ichinomiya M, Nouchi R, Miyauchi C, Takeuchi H. (2012) A GO intervention program for enhancing elementary school children's cognitive functions and control abilities of emotion and behavior: study protocol for a randomized controlled trial. *Trials 2012. 13:8.*

Villani C., Torossian C. (2018). *21 mesures pour l'enseignement des mathématiques.* Ministère de l'Education Nationale. France.