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Go Game as Classroom Practice to Learn Mathematics at French Primary Level

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We present classroom research to develop resources to teach mathematics at French primary school by using the game of Go. Go players, teachers, researchers meet at university to produce teaching resources, implement them in the classroom, and have a reflective phase to evaluate and improve the resources. The aim of this classroom research is to study the opportunities provided by the game of Go to learn mathematics and to propose a teacher training course to implement the game of Go in French primary schools in accordance with the French syllabus.

Keywords: primary school, game of Go, French syllabus, teacher resources

Fields medal laureate Villani supervised a report on mathematics teaching (Villani et al., 2018) which discusses "the pleasure of playing: avoiding anxiety about learning mathematics at school (p. 15)"[1]. Poirier et al. (2009) showed the relation between game and learning mathematics in primary school. Research has shown the interest of strategy games in teaching mathematics **(**Movshovitz-Hadar, 2011). Among these strategy games, Jancarik (2017) showed "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 et al., 2012). The aim of this classroom research is to study the opportunities provided by the game of Go to learn mathematics and to propose a teacher training course to implement the game of Go in French primary schools in accordance with the French syllabus.

Theoretical Framework

We have just mentioned that that the interest of real games in teaching mathematics in primary school (Eysseric et al., 2012; Jancarik, 2017;

1 Translation by the author of the present article.

Movshovitz-Hadar, 2011; Poirier et al., 2009) also shows the interest of teacher training devices in the use of games at school for mathematical learning in primary school.

The use of games in the teaching of mathematics can be referred initially to Brousseau's theory of didactic situations by Mangiante et al. (2018):

> Game is a metaphor – it has to be understood in a theoretical sense, as a model of the problem to be solved with related conditions. Devolution and institutionalization are two components of the game that the teacher has to play so that the student learns from the situation. In devolution, the teacher acts so that the student plays the game to win and not to please him/her. In institutionalization, the teacher's aim is to help the students recognise the knowledge gained in the game and to transform it into knowledge usable to solve other problems. (p. 150)

Subsequently, this activity of a metaphorical game takes place in a real game: the game of Go.

Using the terminology of Chevallard's anthropological theory of didactics (Bosch et al., 2006), we consider that the Strasbourg Go Club (Strasgo, 2019) is an institution that produces the knowledge to play the game of Go. In the research group, a post-secondary mathematics teacher, member of the Strasbourg Go Club and a secondary school teacher, captain of the French national Go team, provide this knowledge about the game of Go. French primary school is another institution where the mathematical syllabus is taught. About ten primary school teachers and a university didactician provide knowledge about teaching the mathematical syllabus. We study the double transposition of the knowledge of the game of Go and of the knowledge of the mathematical syllabus at the French primary school (Cabassut, 2010). Using the praxeology theory (Bosch et al., 2006), we study different teaching tasks assigned in classes, the means of achieving these tasks and how these means are justified, here from the points of view of the game of Go and of mathematics. 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 et al., 2006, p.134).

Furthermore, the material used in the game of Go (board and stones) enables to work in a new register of representations. For example, the stones could help to visualize the counting. The action of placing the stones on the Go board (Goban) could help to validate or not an anticipated reasoning by realising effectively the action anticipated by reasoning. The registers of representation of the game of Go offer concrete representation (group of stones on the Goban, position on the Goban…) and concrete treatment on objects. The traditional mathematics registers of representation offer different ways to represent objects (numbers represented orally or in writing, code of a position on a grid…) and different treatments on the represented objects

(addition, deductive reasoning…). The student must know how to convert from one register to another and how to process in each register. "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

This research takes place in Strasbourg Research Institute of Mathematics Teaching (IREM)[2] that has:

> 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 et al., 2019 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" (Margolinas et al., 2015, p.901). Once per month the research group meets with the following phases: playing and learning the game of Go, reporting about in-class experiments, sharing produced resources, reflecting on the experiments and conceiving new experiments to implement before the next meeting. The phase of playing and learning the game of Go has two functions: first, to develop the teacher's knowledge about the game of Go, secondly, to reflect as teachers about activities for the pupils to learn the game of Go and the mathematics involved in these activities. Then the activities are experimented by some teachers and their pupils. The phase of reporting about the experiments in the classes and sharing produced resources, reflecting on the experiments, enables to develop an experimentation cycle to refine the lesson. But Clivaz remarks: "the »*refine or not refine*« question was not about designing a better lesson, but it is about »*will we learn more, as professionals, in digging more this topic and redesigning a lesson to analyse what the changes will make for difference in student's learning*«" (Clivaz, 2018, p.178). This kind of discussion is clearly about the professional learning and not just about solving the professional problem".

To analyse the teaching experiment, we use the double approach methodology (Robert et al., 2005):

2 https://mathinfo.unistra.fr/irem/accueil/ UFR de mathématique et d'informatique 7, rue René Descartes - 67084 Strasbourg Cedex France

> This method proposes a twofold approach: on the one hand – in a didactics-centred approach – we developed a general frame-work for analysing 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 the game of Go. It is a strategy game for two players; one player has the black stones and the other one the white ones. The player with the black stones starts the game and more generally all the exercises. The Go board is a grid of lines called Goban. One player takes his turn to place one stone on a vacant intersection point of the board. The stones are not moved. This player captures a stone or group of stones of the opposite colour when they are surrounded by his stones on all orthogonally adjacent points. At the end of the game, the winner is the player who has the greatest number of stones on the board. We adopted the variations of the rules of the Game suggested by the Strasbourg Go Club (Strasgo, 2019).

The Research Group

The research group gathers varied members: a university mathematician (former researcher in pure mathematics and currently researcher in mathematics didactic), a post-secondary mathematics teacher member of the Strasbourg Go club, a secondary school teacher captain of the French national Go team, and about ten primary school teachers (with classes from grade 1 to 5 represented). Some teachers have no experience with the game of Go. Some teachers did not study mathematics as their primary field of study. Some teachers have some experience with the game of Go in a club outside the classroom and in the compulsory courses.

Learning of Game of Go Knowledge

There are different rules of the game. The Strasbourg rules (Strasgo, 2019) are easy to understand and well adapted to a gradual introduction at primary school. In the first meeting of the research group, different rules are introduced: the winner is the player with the greatest number of stones on the board. The discussion is about how the pupils should compare the two numbers of stones. The second rule is the capturing of stones surrounded by stones of the opposite color. Here, different exercises are displayed: show the surrounded group (Figure 1), capture stones in one or two moves (Figures 2 and 3).

Figure 1
Show a Surrounded Group

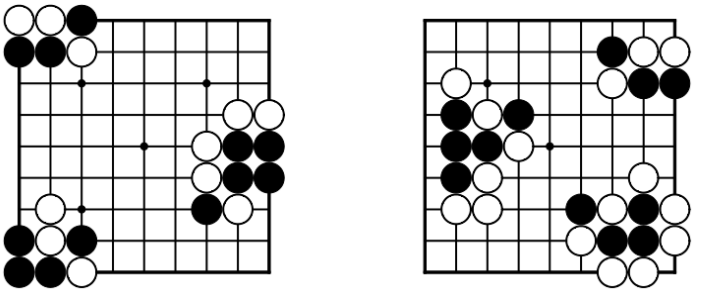


Figure 2
Capture in One Move

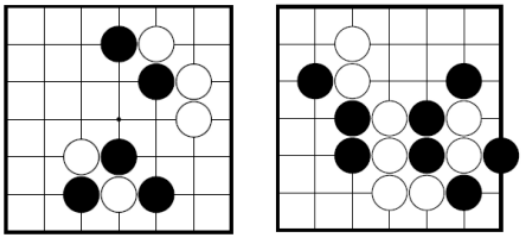
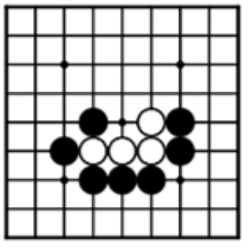


Figure 3
Capture in Two Moves



Another temporary rule is to consider that the game ends when a player has captured one stone and at this stage, the players compare the stones remaining on the board to determine the winner. This rule can be adapted later when players are sufficiently familiar with the game. In the next meeting of the research group, other rules will be presented in order to be transposed in the classroom. For example, the rule to end the game can switch to: the game ends once one player has captured three stones, or five stones, or after an amount of time decided by the teacher. Finally, we'll end up with the official rule about the end of the game: the game ends when both players have passed consecutively. These transpositions to the class can be discussed in the

teachers training group, experimented in class then re-discussed at the next session to be improved or completed.

Another example of transposition of training activity to the class is the following usual exercise: to consider a game in progress, and to ask a player to explain how he would continue the game and for what reasons. The difficulty of the exercises will also increase gradually. In the first capturing problems, pupils will be asked to capture stones in one move. Then, the instruction will be to capture stones in two moves and so on. Pupils will have to reason considering the possible answers of the other player to their first move. These exercises can be given individually to the pupils, or displayed on the classroom board in order to make the pupils think together and explain their choices to the others.

Learning of Mathematical Knowledge

Counting procedures are proposed, by grouping stones in rectangles or lines without the need to count by enumerating (Figures 4 and 5).

Figure 4
Counting by Enumerating

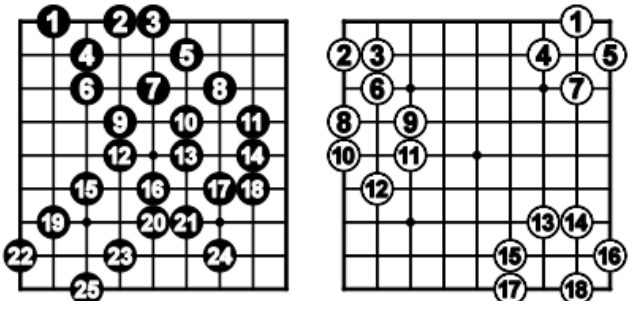
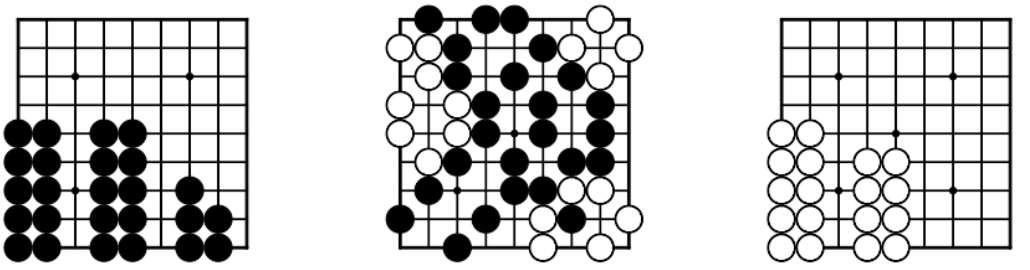


Figure 5
Comparing Without Counting

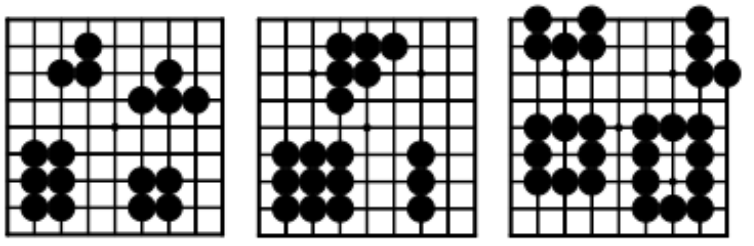


Grouping the stones can offer **representation registers** (Duval, 2006) for different mathematical notions. Grouping in lines of the same length can be a representation register of multiplication understood as the iteration of an addition (for example 20=5+5+5+5). Grouping in a rectangle can be a

representation register of a 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 the decimal number system.

Geometry and geometrical magnitudes (length and area) can be studied with shapes (Figure 6). Are the displayed stones forming a line? Measure the area and perimeter of a territory surrounded by stones, etc. Coordinates can be used on the Go board to specify the moves of a game.

Figure 6
Study of Shape, Length and Area



Data organization can be studied by organizing a Go tournament: how will the different games be planned and the results of the games managed.

Reasoning

Different types of reasoning coexist in primary school (Cabassut, 2005) and the skill "reasoning" is one of the six main skills developed in the teaching of mathematics (Ministère, 2016). We will explore different scenarios which allow in the game of go to work different reasonings. Following the work of Haye (2019), we propose different plays to complete in order to work heuristic reasoning to anticipate who will win and proving reasoning to prove who is the winner. In the exercises below, the player will reason in order to find the appropriate series of moves to capture the opponent's stones (Figure 7) or to count all the possible groups of an indicated number of stones (Figures 8 and 9).

Figure 7
Capture in two moves

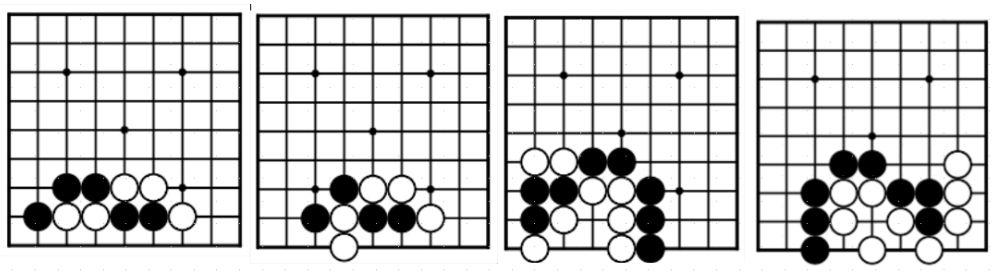


Figure 8
Count the Groups of Three Stones

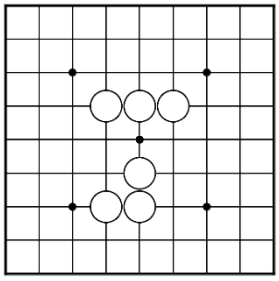
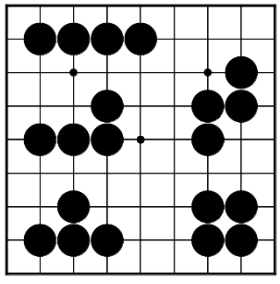


Figure 9
Count the Groups of Four Stone



Feedback of Teaching Experiments

Experiments show that different parts of the syllabus are being worked on, as for example in grade 1, addition (complement to make 10) or lines (horizontal, vertical, diagonal). Pupils seem to represent these notions more easily in the context of the game of Go which seems more familiar and enables to use visual and action registers.

Some teachers value broader benefits of the game of Go. The moral rule is important: do not cheat while playing. Pupils get confidence thanks to the game of Go. The most skillful ones are not always the best in mathematics. Pupils play Go with each other and are used to switching game partners. The social life of the class is improved.

Teachers notice the pupils' motivation to play because the rule of the game are easy to understand. Some pupils who experience languages difficulties (because French is not their mother tongue) find it easier to express themselves during the game. There can be several systems of play: either pairs of pupils face each other on their own boards (Figure 10), or the entire class plays on the classroom board (Figure 11). Studying the situations with the classroom board helps a lot the pupils with difficulties. The difficulties can be on the side of the game of Go (understanding the rules) or on the mathematical side (understanding a mathematical idea).

Figure 10
Players' Pair

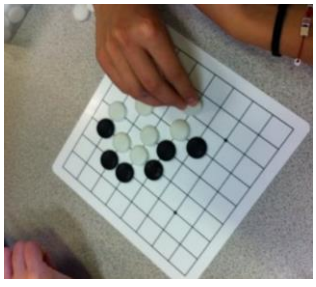
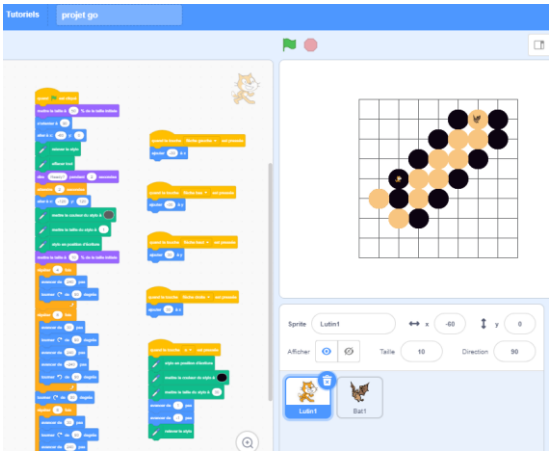


Figure 11
Classroom Board

One teacher has worked on algorithmic and programming (a part of the French syllabus in primary school) by creating Go situations with the Scratch programming language (Figure 12).

Figure 12
A Game of Go with Scratch



Sharing of Materials and Resources

Some activities were elaborated using Go material but without playing the game of Go. A teacher adapted the counting stick (Millet et al., 2007) to learn multiplication tables with labels representing the numbers with rectangles of Go stones (Figure 13).

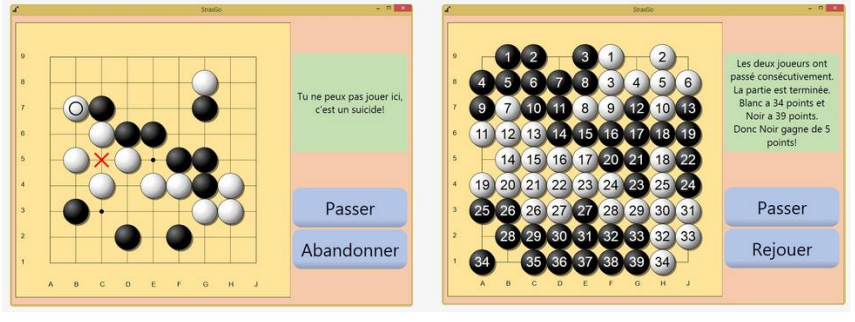
Figure 13

Go Stones Representation for the Multiplication Table of 3

A software (Strasgo, 2019) is available to practice at home against an artificial intelligence (Figure 14).

Figure 14

A Game with Strasgo



Results and Conclusions

With the first experiments, it is possible to move the game of Go from voluntary activities outside the classroom to compulsory activities inside the classroom. **For game of Go knowledge**, the experiments show that it is possible to learn adapted rules and to play Go in primary school. The proposed progression to learn the rule of Go has been well adapted to the variety of classroom situations. From the pupils' point of view, the experiments show that motivation, pleasure, social behavior are developed through Go activities. **Concerning mathematical knowledge,** many parts of the French primary-school syllabus can be taught through the use of Go. The game of Go 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 pupils, it was a first encounter with the game of Go. Next year, familiarity and confidence will improve the teaching

and the learning. The evaluation of the experiments has to become more precise. The group is developing resources and new situations that fit in the syllabus. In the past year, this research project was in an exploration phase with a qualitative evaluation. The evaluation should better specify the developed skills and the criteria to be observed to verify the development of these skills. It would be interesting to have a control group that does not use the game of Go and to observe whether there are significant differences for some evaluations as Haye (2019) did in his doctoral work on the study of the conditions and constraints of implementing the game of Go to learn mathematics in primary school.

The COVID period has made it more difficult to set up such devices in our research group. However, it remains difficult to neutralize some variables. If we use another class as the control group, the teacher variable can bias the comparison. Here, we see one of the difficulties of action research, which remains essentially research with qualitative experiments. Yet, some questions are suitable for a qualitative analysis resulting from our experiments: What do the arguments of the children look like in the tasks of foresight thinking? Can different strategies be identified? Especially in the context of children who do not have French as their mother tongue or who may not yet have sufficient knowledge of the language of instruction: How do they use the different forms of representation or possible register changes?

References

Artigue, M., Bosch, M., Chaachoua, H., Chellougui, F., Chesnais, A., Durand-Guerrier, V., Knipping, C., Maschietto, M., Romo-Vázquez, A., & Trouche, L. (2019). The French didactic tradition in mathematics. In W. Blum et al. (Eds.), *European Traditions in Didactics of Mathematics. ICME-13 Monographs* (pp. 11–56). Springer. https://doi.org/10.1007/978-3-030-05514-1_2

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

Cabassut, R. (2005). Raisonnement plausible versus raisonnement de nécessité: où est la frontière? In *Actes du XXXIIe Colloque COPIRELEM*, IREM de Toulouse, https://publimath.univ-irem.fr/numerisation/WO/IWO05014/IWO05014.pdf, 1–16.

Cabassut, R. (2010) The double transposition in mathematisation at primary school. In *Proceedings of CERME 6*, January 28th-February 1st 2009, Lyon France © INRP 2010, 2156–2165.

Clivaz, S. (2018). Lesson study as a fundamental situation for the knowledge of teaching. *International Journal for Lesson and Learning Studies*, *7*(3), 172–183. https://doi.org/10.1108/IJLLS-03-2018-0015

Debellis, V., & Goldin, G. (2006). Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies*

in Mathematics, 63(2), 131–47. https://doi.org/10.1007/s10649-006-9026-4

Duval, R. (2006). A cognitive analysis of problems of comprehension in a learning of mathematics. *Educational Studies in Mathematics 61,* 103–131. https://doi.org/10.1007/s10649-006-0400-z

Eysseric, P., Simard, A., & Winder C. (2012). Exemple de dispositif de formation à l'utilisation des jeux à l'école pour les apprentissages mathématiques. In J.-L, Dorier & S. Coutat (Eds.), *Enseignement des mathématiques et contrat social: enjeux et défis pour le 21e siècle. Actes du colloque EMF 2012,* 324–336. https://hal-amu.archives-ouvertes.fr/hal-02052826/file/EMF2012GT2EYSSERIC.pdf .

Haye, T. (2019). *Etude des conditions et des contraintes d'implémentation d'un jeu de société à l'école, comme vecteur d'apprentissages mathématiques. Cas du jeu de Go au cycle 3.* Thèse. Université de Montpellier. https://tel.archives-ouvertes.fr/tel-02457092/document

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

Mangiante-Orsola, C., Perrin-Glorian, M.-J., & Strømskag, H. (2018). Theory of didactical situations as a tool to understand and develop mathematics teaching practices. *Annales de didactique et de sciences cognitives*, Special Issue English-French, IREM de Strasbourg, 145–173. https://doi.org/10.4000/adsc.334

Margolinas, C. (2013). Task design in mathematics education. *Proceedings of ICMI Study 22 (Vol. 1).* Oxford, HAL Id: hal-00834054 https://hal.archives-ouvertes.fr/hal-00834054v3 .

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 47,* 893–903, https://doi.org/10.1007/s11858-015-0698-z

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

Ministère de l'Education Nationale. (2016). Compétences travaillées en mathématiques : raisonner. EDUSCOL. Mars 2016. https://eduscol.education.fr/document/17224/download .

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,* (pp. 117–140), Springer. https://doi.org/10.1007/978-0-387-09812-8_8

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. https://doi.org/10.1007/s10649-005-5890-6

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 13,* article number 8. https://doi.org/10.1186/1745-6215-13-8 .

Villani, C., & Torossian, C. (2018). *21 mesures pour l'enseignement des mathématiques.* Ministère de l'Education Nationale. France. https://www.education.gouv.fr/media/11072/download .

Wikipedia. (2020). *Hikaru no Go.* Wikipedia, The Free Encyclopedia. Retrieved on the 26 February 2020 from: https://en.wikipedia.org/w/index.php?title=Hikaru_no_Go&oldid=939367125

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