Social Facilitation Due to Online Inter-classrooms Tournaments

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Abstract. In this paper we explore the impact of an inter-classrooms math tournament implemented through internet. The strategy is to increase learning through intra-classroom collaboration generated by inter-classroom competition. Ten fourth grade classes with all their students from eight schools participated. During previous weeks students practiced on-line and played a cloud based board game designed to learn word problems. Afterwards, all students participated on an inter-classroom tournament. They played on-line synchronously during 60 min. The game was played in dyads formed from different schools. The list of each classroom average score was published every 5 min on each student computer. We found an important social facilitation effect: a significant improvement on the performance of male students weak on math, and therefore a reduction on the performance gap between mathematically weak and strong male students. The improvement of female students weak on math was also significant but lower.

Keywords: Game based learning · Learner affect · Motivation and engagement · ICT inclusion for learning

1 Introduction

There is ample evidence that schools have not changed dramatically over the last few centuries [4, 15]. Even after the introduction of textbooks, students continue to spend their class time by primarily listening to lectures and taking notes. Why does education seem so immune to transformations? Labaree [15] argues that education is a far more complex domain than other areas. For example, he compares a typical nuclear power facility with a school. Since every component of a nuclear facility is causally interrelated with the others, it is much easier to trace the source of any deficiencies and fix them accordingly. Schools, conversely, are composed of completely independent units: isolated classrooms. If one classroom performs well, it does not immediately produce an effect on parallel classrooms. Superintendents and principals generally track mean performance across classrooms and, on average, good and bad performances cancel each other out. Therefore, on the whole, the school remains highly stable. In this paper, we provide some empirical evidence to suggest that this situation can be radically transformed by information technology, game-based learning, and, in particular, by online inter-classrooms tournaments.

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On the other hand, from a psychological point of view, learning requires several cognitive resources: working memory, long-term memory, attention, unconscious and conscious mechanisms, representation mechanisms and metacognitive processes [20]. When starting with a problem, perceptual pattern detection and nature of problem recognition processes are activated. A strategy is then selected from long-term memory. This selection depends on the familiarity with the problem. If the problem is unfamiliar, basic procedures are explored and used. After developing fluency through extensive practice, attentional resources are then freed up. Strategy discovery processes then become activated, leading to the combination of old strategies and the construction of new ones. Therefore, learning requires practice. With each new level of complexity, practice is required to ensure proficiency and free up attentional resources in order to start a new cycle of discovery and further learning.

However, practice requires strong motivation. Therefore, the main challenge facing the teacher is motivating their students. In order to do so, teachers need effective tools with which to connect with their students and engage them in learning activities. Play is a natural tool and is ideal for repetitive practice [5]. While playing, students are constantly practicing. Social play is even more engaging than playing alone, and it is arguably even more natural. It is an ecologically-valid educational strategy used by mammals and several other animals [17]. In a classic study from 1898 [23], Triplett found that cyclists were faster when competing against others than when racing alone. This effect is called social facilitation and has subsequently been found in other tasks and other animals [26, 27]. Brains have evolved for action [11], but actions with others are more engaging. The hunter-gatherer brain is particularly well-adapted to collaborating and learning from others in order to compete with neighboring groups. Intergroup competition may therefore be older than our species' heavy reliance on cultural evolution [13]. Tribal warfare is a chronic occurrence [7] and by no means the exception. However, cooperation is a very powerful weapon for competition. It evolved not due to benevolence, but because it provides an advantage when it comes to survival [12]. "Us against Them" situations generate a strong motivation to learn together, compare strategies, help each other, improve and keep trying. In these situations, learning is a pressing matter and an urgent need, as well as being more meaningful. The brain immediately perceives the benefit of practicing, and the benefit is not decades away in the future. This is an important emotional effect that can boost performance. These findings from anthropology and evolutionary psychology suggest that there is a big opportunity for team games in education. Team games capture these biologically primary motives and could therefore be used to increase motivation and learning of academic contents.

Social play is hardwired for learning, but it is better suited to acquiring biologically primary skills [9], such as hunting, fighting and mating. It is not always obviously suited to academic knowledge, such as fractions or word problems. Academic contents are biologically secondary knowledge [9]. They are the product of several millennia of cultural development, and are not easily grasped. They require thousands of hours of intensive practice and guided instruction. Furthermore, when there are several children playing simultaneously, managing them and making sure they are learning is a complicated task. Even in games with very well-defined and widely-understood rules, the challenge of classroom management is far more complex than in a traditional lecture-based class.

Nonetheless, there is a long history of using team games in classrooms for academic subjects [14, 16, 21] and tournaments [21]. For example, Slavin [21] proposes Team-Games-Tournaments (TGT), in which every week students from a class compete against members of other teams from the same class. In mathematics, Edwards et al. [8] measured the effect of a non-simulation (no attempt to simulate aspects of reality), non-computer based math game played intra class by teams of 4, competing in a tournament over the course of 9 weeks. Ninety six 7th graders from two low ability and two average ability classes were taught equations, and met twice per week. One low ability class and one average ability class participated in the tournament, while the other two classes were control groups who were taught following traditional classroom methods. Significant interaction and improvement was obtained in the low ability class, and learning rates were more similar in the experimental classes than in the control ones. This is a game where math skills are needed for winning, and which allows for peer tutoring. During the game, the students receive immediate feedback, while each individual's score is made publicly available.

From the teacher's point of view, team games provide a unique environment for teaching. The teacher can easily form emotional connections with the students, empathize with them and be their leader. Our brains have also evolved to follow a leader in our conflict against other tribes. This opportunity is optimized when teams comprise the whole class. In this case, the students can truly trust their teacher as there is no conflict of a teacher helping rival teams. Instead, they only provide academic and emotional support to their own class. Empirical evidence shows that students learn the most in classrooms where the students feel they can trust the teacher [6]. In inter-class competitions, students can truly trust their teacher. Therefore, they should be more open to receiving instructions and feedback from the teacher. Additionally, in inter-class tournaments, students identify as members of their class. With massive online synchronous tournaments between classes, we can recreate the powerful "Us" against "Them" environment and, therefore, activate ancestral intra-group collaboration and social motivation mechanisms.

In this paper, we reveal empirical evidence from a game played by teams. Each team is formed by all of the students in a class. This is an innovation and a challenge. According to the cooperative learning literature [14, 16, 21], large teams are not efficient for academic learning. The larger the group size, the fewer the members that can participate [14]. Edwards et al. [8] suggest that when teams have more than 5 members, it does not allow the majority of the students to participate. In this paper, we explore the effect of large teams. Some classes have more than 30 students. Another difficulty is that classes are of different sizes, ranging from 20 to 40 students. Moreover, the classes are not homogenous. Instead, they comprise students of very different levels of ability. Mixed-ability classes are an extra challenge when the teacher has to make sure that all of the students have to learn.

To the best of our knowledge, games involving teams made up of a whole class are not used for academic learning. In [3] we reflect on several years of experience with massive computer-based team tournaments and in [1, 2] we look at massive online multiplayer tournaments for mathematical modeling that are held once or twice a year, with teams from hundreds of schools competing against each other. However, these were teams of 12 students selected from a class or from several classes in the same grade level at each school.

2 Methods

Fourteen entire 4th grade classes from 12 schools prepared for an inter-classroom tournament at the end of 2015. All of the schools are in low socio economic status (SES) communities. Prior to the tournament, the schools participated in three training sessions. The first training session was held during the fourth week of October. In total, 271 students practiced word problems using a non-game mode of the ConectaIdea web-based computer platform. This is a platform where the classroom teacher and a remote teacher track student performance in real time, detect which students are having difficulty, and provide just-in-time support using a chat function included in the platform. Later, during a session held in November, 282 students played the *Espiral Mágico* game within their class. Subsequently, in another session held one or two weeks later in November, 255 students again played *Espiral Mágico* within their class (Fig. 1). *Espiral Mágico* is an online board game included in the ConectaIdea platform. This game is designed to help students learn how to tackle word problems. After these 3 training sessions, the tournament was held on December 9th, involving 217 students (87 girls and 130 boys) from 10 classes, with an average age of 9.99 years and a standard deviation (SD) of 1.90 years. The average class size was 21.7 students, with the smallest class comprising 17 students and the largest 29. During the tournament, all of the classes played against each other synchronously for 60 min. Four of the classes could not join the tournament due to scheduling difficulties. Therefore, the statistics and results that are presented below are taken from the 10 classes that participated in the tournament. During the tournament, the students played the same game that they had played in the two final training sessions, though this time it was played using the inter-classroom tournament mode. In this particular mode, the game is played by pairs of students from different schools that compete against each other, but the score for each class is the average score for all of the students in the class. Each class' score is continuously updated and displayed as a ranking every 5 min on each student's computer.

Why use a board game? According to the National Mathematics Advisory Panel [24], board games are "particularly effective in improving low-income preschoolers' numerical knowledge and reducing discrepancies in the numerical knowledge that children from low- and middle-income homes bring to school." They are engaging and effective for classroom context [18]. *Espiral Mágico* is a board game that has been designed to practice word problems using the curricular content selected by the teacher. Why word problems? As stated in the National Mathematics Advisory Panel report [24], word problems are the most challenging curricular content in elementary school mathematics, and they are an essential prerequisite for learning algebra. Furthermore, two topics from the curriculum were selected for the tournament: "properties of 0 and 1 for multiplication and divisions", and "solving equations and inequations using addition and subtraction with natural numbers up to 100". Therefore, the word problems that were presented required the use of these two curricular contents. Examples of such

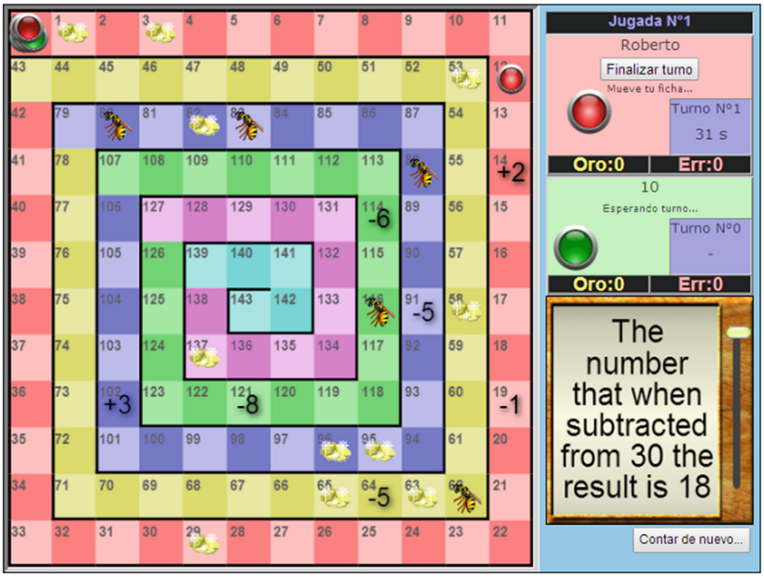

Fig. 1. Screen shot of the *Espiral Mágico* board game posing a word problem. It is a spiral path that starts in the upper-left corner, where the start cell is located. The path ends at the center of the board, where the goal is located. It runs clockwise. The word problem is located in the bottom right of the screen. The solution gives the number of positions that the player has to move one of her three beads. The player chooses the most convenient bead. If, after moving the bead, it ends up in a cell containing a number in large writing, then she has to move the bead forwards or backwards the corresponding number of squares. If the bead ends up in square with a monster then her bead goes to the start cell. If her bead ends up in space containing one of their rival's counters, then that rival's bead goes back to the start cell. Therefore, the player has to strategically select which bead to move. The player that reaches the goal cell first gets extra points and the play is over.

word problems include (Fig. 1): "The number that when subtracted from 30 the result is 18", "The number that when added to 18 equals 36", "the result of adding 12 and 0, divided by 10", etc.

The tournament is run by a tournament administrator. This is an independent teacher that remotely presents the game and the participating schools, cheers the teams along and constantly announces the updated ranking. He has the support of a video streaming engineer who broadcasts one way video to every class, and he also has the support of a chat manager, who answers questions from teachers and students (Fig. 2). Every class connects to a web page at a certain pre-defined time. Each class plays as a team. Every 5 min, a ranking with each class' score is published. However, the score of each individual student is also recorded and specific feedback is automatically given to each student according to his particular performance. As [14, 21] underline, individual accountability and team goals are two critical features in collaborative learning. During the tournament, each student solved an average of 11.8 word problems, with a SD of 4.3 problems.

Fig. 2. From left to right, (i) one engineer tracks the video streaming and supervises the students' connection to the game, one teacher manages the video streaming chat, and one teacher introduces and runs the tournament via video streaming and announces the class ranking every 5 min, (ii) one of the ten participating classes; (iii) another of the ten participating classes. The teacher that runs the tournament can be seen in the projections on the classroom walls.

In each class we define students that are weak at math as those with a grade point average (GPA) that is below their class average. The rest of the students are defined as being strong at math. From herein after, we will refer to them as the weak and strong students, respectively. The GPA is calculated based on several online tests taken by the students throughout the year using the ConectaIdeas platform. All of the classes took the same tests. The scale goes from 1 (the minimum) to 7 (a perfect score). The mean GPA in math for the students that participated in the tournament was 4.5, with a SD of 0.86. Overall, the tournament featured 113 weak students and 104 strong students. The mean GPA for the weak students was 3.93, with a SD of 0.63. On the other hand, the mean GPA for the strong students was 5.17, with a SD of 0.56. Note that there is a significant gap between these two means. As shown in Fig. 3, the strong students scored 1.24 points more than the weak students. If we measure this gap in terms of the SD of the GPA for the weak students, the result is 1.24/0.63 = 1.97 SD. Measured in terms of the SD of the mean of the GPA for the weak students, this gap is 20.5 SD. This is not only statistically significant, it is a huge gap.

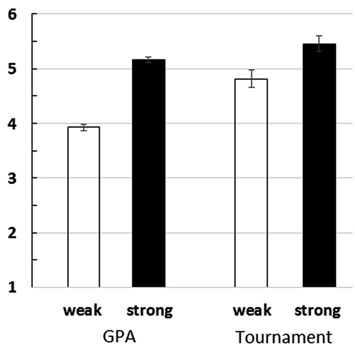

Fig. 3. GPA and performance during the tournament by weak and strong students, shown with confidence intervals.

3 Results and Discussion

The mean performance by the students during the tournament was 5.1, with a SD of 1.65. As shown in Fig. 3, the mean performance by the weak students was 4.82, with a SD of 1.74. On the other hand, the mean performance by the strong students was 5.45, with a SD of 1.47. Therefore, the mean performance by the weak students was 0.64 points lower than the mean performance by the strong students. This is 50.8 % of the aforementioned gap between their respective GPAs. Expressed in terms of the SD of the performance by the weak students, the gap is 0.64/1.74 = 0.36 SD. Although a significant gap, it is much lower than the gap of 1.97 SD between the GPAs. In fact, the gap that was witnessed during the tournament is only 18.4 % of the gap between the students' GPAs. This result means that during the tournament the gap between the strong and weak students is significantly reduced. This is an important finding. However, there can be several possible explanations.

3.1 Possible Explanations Based on Differences in Difficulty Level

One possible explanation for this result is that the math included in the game is easier than the math used in the online tests to calculate the GPA. If this explanation were valid, then all of the students should have done better. Since the strong students are close to the maximum score, their improvement during the tournament is less than the improvement made by the weak students, and therefore the gap is reduced. However, the mean performance by the strong students in the tournament did not differ much from the mean of their GPA. Although it is a statistically significant difference, they are still far from 7, the perfect score. In other words, they only performed slightly better. Their mean improved by only 0.28 points compared to their GPA. In terms of SD, this improvement is 19 % of the SD of the scores from the tournament and 50 % of the SD of the GPA. Moreover, 34.6 % of the strong students performed worse during the tournament than their respective GPA.

Another possible explanation is that there were two different kinds of math questions used in the *Espiral Mágico* game: very easy and very difficult. If this were the case, then there would be no medium-difficulty problems, and therefore all of the students would have performed similarly. However, the variation in student performance for the tournament was very high compared to the variation in GPAs. The SD of the performance by strong students during the tournament was 1.47. This is much higher than the SD of their GPAs, which was 0.56. Similarly, the SD of the performance by the weak students during the tournament was 1.74, which is much higher than the SD of their GPAs, which was 0.64. Therefore, this second explanation does not match the data. After ruling out these two possibilities, the most plausible explanation is that the weak students learned more in the tournament than the strong ones.

3.2 Possible Explanation Based on the Game-like Nature of the Activity

One possible cause of the significant improvement by the weak students is the game-like nature of the activity. To explore this hypothesis we shall analyze the data from the training sessions. As mentioned previously, three training sessions were held before the tournament. In the first session, the students used the same ConectaIdea web platform with the same type of word problems as those used in the tournament, although the platform was not set to game mode. The platform provided word problems and gave instant feedback. The teacher tracked the students' performance in real time using her tablet and provided support to those who were struggling the most. In this training session 146 students participated that later also participated on the tournament. 75 were weak students and 71 were strong students. The mean performance by the weak students was 4.61, with a SD of 1.79. The mean performance by the strong students was 5.63, with a SD of 1.42. This means that in this non-game-based activity there is a significant difference in performance between the weak and strong students; a gap of 1.02 points. This is similar to the gap between the mean GPA for the weak and strong students. Moreover, as shown in Fig. 4, there is a significant correlation between student GPA and performance in this non-game-based activity: student performance = 0.93 GPA + 0.80 with an R^2 of 0.20. However, the correlation between GPA and student performance during the tournament is close to zero, with an R^2 of 0.04. Thus the results from this training session confirm that the *Espiral Mágico* game was not easier than the normal tests and that it did not mostly contain only easy or difficult problems. They also suggest that the game-based nature of the activity makes a difference to the weak students.

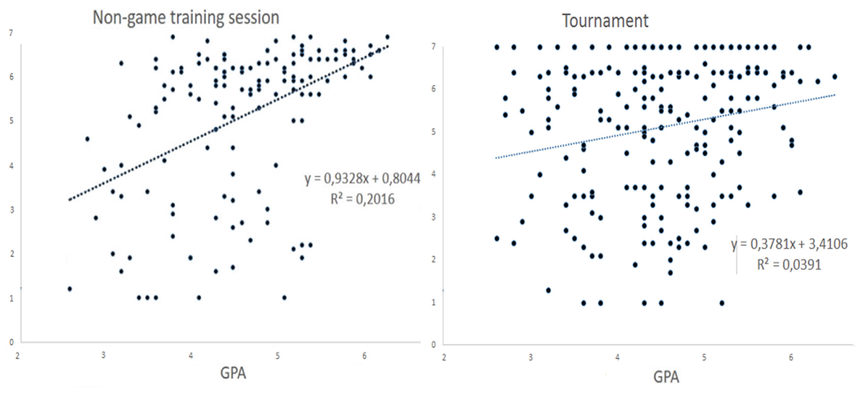

Fig. 4. GPA and performance during the non-game-based training session by the 146 students who participated in the training session, and GPA and performance during the tournament by the 217 students who participated in the tournament.

3.3 Possible Explanation Based on the Inter-classroom Nature of the Tournament

The hypothesis regarding the game-based nature of the activity includes two probable causes for the improvement made by the weak students: the game-based nature of the activity and/or the inter-classroom nature of the tournament. In order to try to disambiguate these two possible causes, we shall now analyze the next two training sessions. These were sessions where the students played the same game using the same type of word problems. In these two warm up tournaments, the students did not play against students from other classes. Instead, the students played one-on-one against another student from their class, without forming teams. 145 students participated in the second training session. The mean performance by the students during the training session was 4.76, with a SD of 1.92. This was slightly higher than the mean GPA, which was 4.49. Here, the difference is just 0.27 points, which corresponds to 14 % of the SD of the students' performance during this training session. The gap between the weak and strong students was 0.71 points. 156 students participated in the third training session. In this case, the mean performance by the students was 4.30, with a SD of 1.59, which is 0.19 points lower than the mean GPA. This difference is 12 % of the SD of the students' performance during this final training session. The gap between the weak and strong students was 1.04 points. These facts therefore suggest that it is not just the game-based element that leads to significant improvement by weak students; instead it may be the social nature of competing between classes. The "Us" against "Them" ancestral mechanism, which is more strongly activated in inter-class tournaments, appears to be the most important driver of motivation and improvement among weak students.

In order to explore this motivational mechanism we can get insights from the evolutionary psychology literature. According to Geary [10], boys tend to form larger groups, which is normal when preparing for inter-tribal conflicts. Girls instead tend to form much smaller groups, with more intense and lasting relations. Thus, boys are more easily motivated by large group collaboration in preparation for inter-group conflicts. Therefore, a prediction from evolutionary psychology is that if the inter-classrooms nature of the tournament is indeed the mechanism that boosts performance among weak students, then there should be a gender difference in the improvement made by weak students. Since the tournament provided us with information on weak and strong male and female students, then we can confirm or refute this prediction.

There were 89 girls that participated in the tournament, 42 with a weak GPA and 47 with a strong GPA. As shown in Fig. 5, the mean GPA among the weak female students was 4.00, with a SD of 0.56, while the mean GPA among the strong female students was 5.18, with a SD of 0.60. In other words, there was a gap of 1.18 points between the two groups. This gap represents 2.1 SD of the GPA for the weak female students. On the other hand, the mean performance during the tournament by the weak female students was 4.37, with a SD of 1.97. The mean performance during the tournament by the strong female students was 5.53, with a SD of 1.42. This performance is slightly higher than the mean performance by the strong male students, which was 5.33, with a SD of 1.52. The gap between the weak and strong female students during the tournament was 1.16 points. This is very similar to the gap in their GPA. However, it now represents only 0.59 SD of the GPA for the weak female students. This means that the gap during the tournament is 28 % of the gap in GPA. In the case of the boys, the weak male students had a mean GPA of 3.89, with a SD of 0.68, and the strong male students had a mean GPA of 5.15, with a SD of 0.52. This means that the gap is 1.26 points, which is 1.85 SD of the GPA for the weak male students. During the tournament, the mean performance by the weak male students was 5.08, with a SD

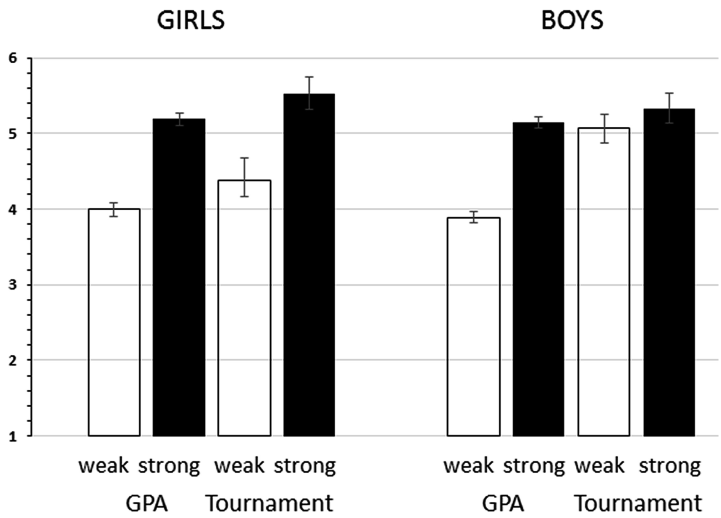

Fig. 5. GPA and performance during the non-game-based training session, and GPA and performance during the tournament, shown with confidence intervals.

of 1.53, while the mean performance by the strong male students was 5.33, with a SD of 1.52. In this case, the gap is just 0.25 points. It is much lower than the gap in GPA. In terms of SD, the gap in the tournament is 0.16 SD of the GPA for the weak male students. Therefore, the gap during the tournament is 9 % of the gap in GPA. This is a huge decrease; much bigger (3 times) than the decrease in the gap for the girls. The empirical evidence regarding the gender difference for the improvement made by weak students therefore seems to confirm the hypothesis that this improvement is mainly caused by the inter-classroom nature ("Us" against "Them") of the game used during the tournament, and not just the game-based nature of the activity itself.

An independent study during a similar tournament held in December 2014 confirms the hypothesis that the main motivation comes from playing against a rival from another class. In this 2014 tournament, eight 4th grade classes competed during the official tournament. While playing the game, a quick, two-question survey was conducted. The first question was: Who are you playing against? The second question asked the students to select one of the 6 options that were listed, regarding their preference for doing math exercises. From a total of 159 4th graders that competed in the tournament, 128 answered the survey. As shown in Table 1, 56.3 % prefer doing exercises by playing a social game against a rival; particularly if the rival is from another school. However, it is interesting to note that girls selected the option of doing exercises on their own in their notebook much more than boys. Theses gender differences agree with predictions from evolutionary studies. According to Geary [10], "selection pressures favored the evolution of motivational and behavioral dispositions in boys and men that facilitate the development and maintenance of large, competitive coalitions and result in the formation of within-coalition dominance hierarchies".

Table 1. Preferences for practicing math problems

	Males	Females	Total
I prefer doing exercises using the *Espiral Mágico* Board Game with a rival from another school	33.80 %	25.90 %	30.50 %
I prefer doing exercises using the *Espiral Mágico* Board Game with a rival from my class	29.70 %	20.40 %	25.80 %
I prefer doing exercises using the *Espiral Mágico* Board Game with a bot rival	9.50 %	5.60 %	7.80 %
I prefer doing exercises on my own on the computer	12.20 %	16.70 %	14.10 %
I prefer doing exercises on my own in my notebook	5.40 %	24.10 %	13.30 %
I prefer doing exercises on the whiteboard	9.50 %	7.40 %	8.60 %

4 Conclusions and Practical Implications

There is a long tradition of collaborative learning and team-based activities. From 1898 to 1989, over 500 experimental and 100 correlational cooperative learning studies have been conducted [14]. According to Slavin et al. [22] cooperative learning is very effective in elementary mathematics education. However, it is not used much in schools. Mevareth and Kramarski [16] argue that the main reason that co-operative learning has not always fulfilled its potential is the difficulty of guiding students in how to monitor, control and evaluate their learning. Without this guide, metacognition is not promoted and therefore student interactions are ineffective. Slavin [16] has another potential explanation. He cites observational studies which document that cooperative learning is still informal and does not include group goals or individual accountability.

However, with synchronous online inter-class tournaments there is a real opportunity to overcome these difficulties. According to Johnson et al. [14], in cooperative learning the most important element is positive interdependence: "a clear task and a group goal must be given so that students must believe that they sink or swim together". With the synchronous online inter-class tournament there is a common goal, which is shared by the whole class. This key element is explicitly highlighted by publishing the class rankings while students are competing against other classes. In fact, in the implementation we have described, the ranking is published every 5 min in order to continuously remind students of the shared goal. Another key element is individual and group accountability [14]. In these tournaments, the platform also keeps track of the performance of each individual student. The game also includes instant feedback and metacognition. For example, in the training sessions the teacher can freeze the game, as can be done in basketball, and can pose open questions that can be answered as free text. The teacher is therefore transformed into a coach, who is constantly providing the class with cognitive and emotional support. The emotional connection with the students is therefore hugely facilitated. On the other hand, the tournament presenter also has a critical role in promoting metacognition. This role is particularly intensive in the training sessions, where the game is played before the official tournament. The presenter comments on the strategies developed by students from different classes, encourages the comparison of strategies, as well as encouraging students to reflect on the mathematical concepts and methodologies.

The results from a 2015 online inter-school tournament are very promising. 217 students prepared over the course of three training sessions and then participated in the tournament. There was a huge decrease in the performance gap between strong and weak students. This decrease was caused by an improvement among the weak students. It seems that the ancestral and social game-based nature of inter-group conflict is a very important motivational mechanism for these students. The improvement was more significant among male students. This is an interesting finding, which agrees with predictions taken from evolutionary psychology.

Traditional mathematics classes dedicate a significant amount of time to practice. Notebooks and worksheets are full of exercises. However, the proportion of personalized feedback received from the teacher or peers is very low. Web-based games facilitate a practice strategy, with constant, personalized feedback, detailed monitoring of each student's progress, balanced coverage of the curriculum, as well as opportunities for metacognitive reflection and social learning. However, online inter-school tournaments provide a unique and critical benefit: the classroom is no longer isolated. Classrooms can be connected to each other in an active, synchronized network. In this case, each class competes against the other classes. Therefore, the ancient tribal hunter-gatherer emotions and group identity sentiments are activated and with them emerges intra-class collaboration and a high level of engagement.

According to [19], games and gamification are the experimental petri dish for 21st century social thought, and they represent a rethinking of the assessment mechanisms used in schools to make them more effective and more democratic. However, most of the motivational mechanisms that have been used in gamification are aimed at the individual [25]. The ancestral inter-group motivational mechanisms have been underused in education. At most, they have been used with small teams belonging to the same class. The experience obtained from inter-classroom, synchronized online tournaments opens the door to new opportunities. It provides a strategy for connecting classrooms, for reducing teacher and classroom isolation, and for implementing new forms of learning and engagement that were previously impossible without the latest information technology. The impact is very interesting and powerful. It attracts the attention and motivation of students, particularly those who are weaker at math and harder to motivate. This extra motivation and energy boosts their performance and reduces the academic gap with students that are stronger at math. The data suggests a very important hypothesis: part of the academic gap is due to motivation, not ability.

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