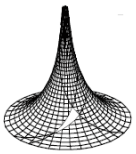

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Group Work at High School According to the Method of Tamás Varga

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Abstract. The aim of our research is to develop students' logical thinking. For this reason, Hungarian mathematics teachers need to be encouraged to try new methods which induce greater student involvement. Research all over the world prove that self-instruction or self-verbalizing has high effect on the learning process. This was one of the key elements of Tamás Varga's experiment in high school. In our classroom experiments we are using a special cooperative method from Kagan among 14-18 years old students, called Sage and Scribe structure. We are looking for the answers to the following question: Does this method make mathematics lessons more enjoyable and more comfortable for students? Furthermore, we assume this structure could open the gate toward other collaborative and cooperative teaching technics.

Key words and phrases: Teaching method, group work, pair work, teaching algebra, classroom experiments.

MSC Subject Classification: 97D40.

Motivation and background

The original aim of our research is to help Hungarian mathematics teachers to make lessons more interactive, enjoyable and help the students understand the logic of

mathematics instead of memorizing rules and algorithms. Cooperative education was important in the work of Tamás Varga, where the first motivation of the project came from.

The reform of Tamás Varga was performed in secondary school also as a smaller experiment. Its center was inquiry-based teaching. Children had to learn extra topics to improve their logical thinking, they got regular homework for revision and they worked most of the time in groups even if a class had forty members. This evidence and the inspiring story of his experiment have turned us toward cooperative teaching and learning.

Theoretical background

The book of the Johnson brothers – Joining together: group theory and group skills – is one of the most comprehensive cooperative learning material which available for educators (Johnson & Johnson, 1979), listing three main features of cooperative teaching and learning. The first is positive interdependence: group members must synchronize their efforts in order to achieve success. The second one is the face-to-face promotive interaction: members should support and encourage each other. The third key element is individual accountability, as students must feel personally responsible for completing the task. The importance of this is almost trivial in school situations, but realisation is not obvious. (Gillies, 2016)

Cooperative learning improves interpersonal and small group skills, but students must be trained to work as described before. Many researches proved that just giving them tasks to work together is not enough. There are several articles which give examples of cooperative lessons, and useful advices and books how to manage the process (Kasi, 2012). It is widely accepted that if a teaching method's effect size (Cohen's d) is above 0.4 it is worth using it, and above 0.6 it is good. A meta-analysis from Turkey, 2015 provides 0.59 as an effect size for cooperative teaching and learning. This number differs between topics, assigning to algebra the best, to geometry the second-best effect size. (Capar & Traim, 2015). John Hattie and his group made a huge meta-analysis with more than 900 articles, and they received the same rate (Hattie, 2012). According to an English website which containing research results, the effectiveness of cooperative teaching and learning is not so positive in every case; There are ten meta-analyses, with five conducted in the last ten years, suggesting that collaborative learning strategies can improve learning.

However, the effects vary between 0.09 and 0.91 and there is no clear explanation of why this spread occurs (Education Endowment Foundation 2018).

In summary, literature is mostly positive about cooperative teaching and learning, therefore it is worth exploring the topic in Hungary.

Actual situation

Our research strongly needed an overall picture of Hungarian mathematics teaching habits in connection with cooperative teaching and learning. There are articles about the topic in Hungary, but they are either more than 10 years old (Józsa & Székely, 2004), or they have just a small sample (Pap-Szigeti, 2007). A new PhD thesis, which topic is the measurement of cooperative problem solving did not provide more information about the actual situation (Pásztor-Kovács, 2018). Another PhD thesis gives a more complex picture, but its experiment is also working with just one class for one year (Barczi-Veres, 2016). There are some cooperative trainings for teachers, but we do not know of any which is especially for mathematics teachers. We also know that more and more teachers use group work in higher primary school (among 10-14 years old pupils), but there is no information about the exact proportion. In summary, there is a great need for a large survey to be taken among Hungarian mathematics teachers about their teaching habits to support their daily work.

The Sage and Scribe method

The Sage and Scribe method (Kagan&Kagan, 2009), which is the center of our experiments, is created for worksheet work, but instead of doing it alone, students work in pairs with one worksheet. For the first problem, the Sage tells the Scribe how to solve the problem and the Scribe records the work. The Scribe's responsibility is to help the Sage when it is needed. Students switch roles frequently.

The pairs are formed by the teacher according to two aspects. Firstly, pairs should not be best friends nor enemies to be able to concentrate on the work (Kagan&Kagan, 2009). Secondly, they should have similar mathematics abilities. Therefore, as a practical guideline we had said to the teachers to divide the class into three groups: 1: Most talented students. 2: Average students in mathematics. 3: Students, who struggle with mathematics a lot. The pairs should be formed from adjacent groups.

The method has many advantages, for example students get peer support, encouragement and coaching. They have the chance to receive immediate feedback.

It is worth highlighting the fact, that this method fulfills the three main principles of cooperation easily: positive interdependence, individual accountability and promotive interaction.

In theory, a pair cannot fulfill the task without one another, therefore the positive interdependence realizes itself because of the structure. In connection with this, during the experiments we usually noticed two problems. Firstly, that the Scribe takes over the Sage's role, therefore the pair worked as two individuals after a while. This can be managed through regular verbal reminders of the roles. The other problem was that the Scribe did not pay attention to the task, just wrote down what the Sage told him or her. It was more difficult to manage, but it was useful when the teacher emphasized that the Scribe is do responsible for the correctness of the results. Which means, that the second principle – individual accountability – is also realized by the structure. The third key element is the promotive interaction which was one of our main aim. The structure makes the pair speak and verbalize their thoughts. It is not a discussion, but it is a way toward it. Furthermore, if there is a mistake or a problem which is noticed by the Scribe the pair arrive to an opportunity of discussion.

We assume that the Sage and Scribe method is a good way of creating opportunities for verbalizing. Practicing the method, the students become more comfortable at speaking about mathematics as they had safe circumstances to practice it. They also had a lot more time to listen to each other's thinking, therefore there is more space for metacognition than in traditional classrooms. It is also important that the structure can make practicing more interesting, reducing boredom.

Experiments

Pre-experiments

As a second step, we organized four pre-experiments. One of it was a summer camp for 16 14-year-old children with 10 lessons, the rest of the experiments were in school situation with 15 years old students. One of it was a whole class with 32 students who had

a little above-average mathematics skills, the other two half classes were below average. Both experiment period lasted for 6 lessons.

In those experiments one of the researchers played the role of the teacher. We have chosen basic combinatorics as a topic, as this is closely connected to real life and easy to talk about. In the pre-experiments we applied four-member-groups.

The lessons were carefully planned, but the periods were mainly too short to teach the method step by step without hurry. The change was fast and great for the students, although the topic was not new and we used games and applied other motivations.

We have concluded from these experiments, that learning in four-member-groups is too rapid change for those children who are 14-15 years old, and never used any cooperative technique before. This turned us toward the Sage and Scribe pair-work-technique of Kagan.

The other important result of the experiments was that the topic of combinatorics is probably not suitable for teaching the students how to work in groups. We have noticed that the children were too shy to share their ideas before they could be sure about the correctness of their solutions. They were afraid of having a bad idea. Therefore, we decided to change the topic to algebra and reduced the group size.

Advanced pre-experiments

There were four pre-experiments in the next step in three different schools. The first two half-classes had 12 and 8 members from a small town. The next group was a half-class with 12 members from a bigger city. The students were low achiever 14-year-old students in each class. The fourth class had 17 12-year-old members from the capital and they were high achievers.

During the experiment lessons, students worked on worksheets with the topic of algebra or functions. They got reminders in written form to change roles. The teacher also paid attention to help the students to follow their roles as a Sage and a Scribe. Firstly, the children changed their roles often, later they had longer shifts.

All experiment periods were short (two to six lessons), and the result was mixed. There were students who liked it and found it a useful tool to understand the topic deeply, but some of the children refused the strange method straight away. Teachers found the method useful, but not in every lesson. They said it slowed the lessons due to the short research period. They found it worthy for implementing a longer experiment.

Main experiments

The two main experiments were realized in school situation, and they were shifted in time.

The research tools were the followings: We prepared a worksheet for 2 lessons to train the students for the method. The topic was the revision of an easy topic, with no urge to hurry through it, and it was led manly by the teacher.

The exercises at the beginning were simple number tasks with addition and subtraction with small, whole numbers and fractions or simplification of exponential expressions with numbers and letters.

For example students solved eleven number tasks like "$(-3)+2=?$" then they switch roles. Each sage had to tell two false solutions to test the scribe's attention. Later they had to simplify expressions like "$(3d-4c)-(3c+d)+2d$" but in that case they had fewer tasks. Another type was the following example: „Let's do a competition within each pair. Think about rules in connection with operations with fractions. Write them down shortly (with the Sage and Scribe method). Switch roles after each rule. In every pair the winner is the one who said the last one."

The aim of those tasks was to make it easier for students to accept the strange situation, that they cannot write while they do mathematics.

Right after these two lessons, they returned to the original topic and the original style of teaching and learning with only one change: in every case when students used to work individually, now they had to work in pairs with the Sage and Scribe method. During this period, we did not recommend problems to the teachers. We chose this pattern because this makes the method easily adoptable to an average classroom. The experimental lessons followed each other in time with no non-experimental lessons between them.

Self-evaluation was integral part of our experiment. On the one hand, following each lesson one of the researchers had a brief discussion with the teacher concerning impressions, opinions and further plans. On the other hand, students filled in an attitude test individually after the first and the last lessons, with special focus on self-reflection in some parts. They were asked to evaluate the method and themselves in a five-point scale (Figure 1) in two rounds, comparing each viewpoint to an average lesson. The questions were about the following topics: faithfulness to their roles as a sage or a scribe (1), their activity in lessons (2), their mathematical activity (3), their helpfulness (4), usefulness of the method (9) and atmosphere of lessons (11). They were also required to evaluate their partner's work with the same questions (5-8, 10,12). In the last part there was also room

for personal comments, opinions. We compared the first and the second questioners, which were filled after the first and the last experimental lesson.

The first class had 17 members, at the age of 17. They were studying economics, therefore they had 5 lessons a week instead of 3. The topic was new for students: exponential expressions, functions and equations. It was perfectly suitable for our aim, as these topics require algorithmic thinking, and can be discovered in short, easily consumable units.

The training lessons were fun for them, although questions emerged about the usefulness of the method. They valued themselves quite good after the first lesson (Figure 1). The smaller columns are the standard deviations of the answers. Later students became more and more resistant, therefore we decided with their teacher to give them a fun-lesson, where we practiced the more complicated parts. This attempt was popular among students but did not help in long term. The questionnaire shows what we had also noticed in the students' behaviour: they refused the method. The usefulness (9-10) and the atmosphere of the lesson (11-12) dropped more than one in a five-point scale, although the first four features (1-8) have not changed remarkably. These results show that students followed the roles of the method, they behaved according to the Sage and the Scribe roles, but they did not enjoy it.

The attitude and involvement of teachers play crucial role in the success of classroom experiments. In case of this 17-year-old group their teacher was voluntary in the experiment, willing to learn new methods. However, as students' excitement reduced, he became noticeably unsure of the effectiveness of the project. Students were too close for their school leaving exams which obviously requires individual work, thus they did not see too much point in cooperation. Furthermore, we did not keep ourselves to the original plan, and employed much more pair work in the coming lessons (3-6) then in general, making students insecure. This could also be a strong reason for their resistance.

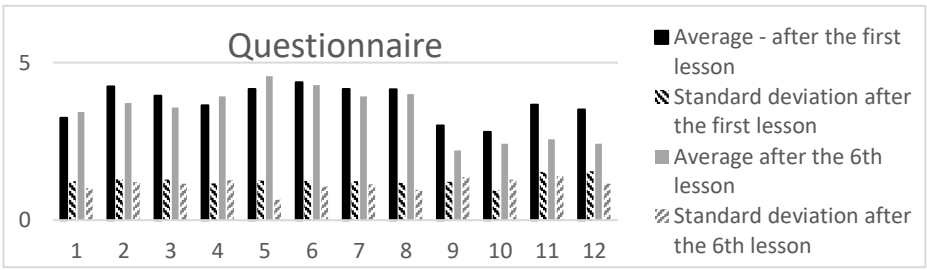

Figure 1. Questionnaire of the first class

The second class was a 14-year-old group with 32 members, in their first year at secondary school. They had 3 lessons a week and have just started to learn algebra. The teacher was an open, young man.

Following the first two introductory lessons, the teacher continued his original style of teaching. He introduced new topics with teacher dominant periods, and he regularly discussed solutions with the whole class. During this short period, he did not notice any significant difference in the students' behaviour aside from the raise of noise level.

Students liked the method, as it is clear in their questionnaire (Figure 2). The answers are almost all about 4 in the five-point scale and have not changed by time. Students valued similarly themselves and their partners. They gave some comments at the end of the experiment which clearly stated that a lot of them liked the method very much. They said it made algebra "less boring". Some of them notes, that it was useful to get more information about the thinking of their mates. They corrected each other's work effectively, which was exactly our aim with the application of the structure. The negative comments mostly complained about their partner. This problem can be handled by mixing pairs in a long-term application. Some clever students also mentioned that they feel themselves more effective when they work alone. Higher noise was uncomfortable for some of them, but the majority did not mind it. Some students were honest, and admitted that they wasted their time on chatting, but it probably still did not cause a significant time-waste, as the students never pay full attention during independent work either.

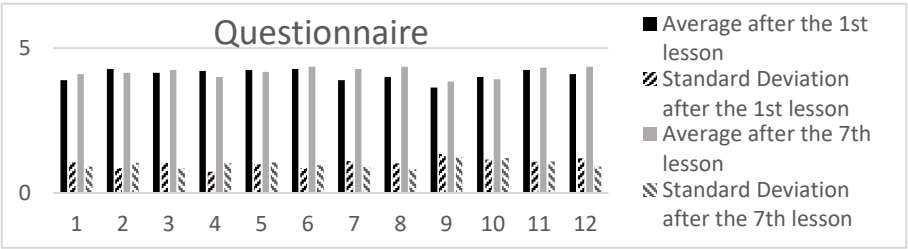

Figure 2. Questionnaire of the second class

Conclusion

As a conclusion we value the whole experiment as a promising one. The Sage and Scribe method could help to improve the quality of mathematics lessons and is easy to adopt with the help of two introductory lessons. Younger students tend to enjoy it, which

was one of our main aim. It is worth to continue the research with longer experiment periods to be able to measure if the method improves students' mathematical performance and understanding and the instructiveness of the class. We would like to concentrate on the topic of algebra among 14 years old students with average mathematical talent. It would be also interesting to get a more detailed view of the dynamics of the pairs.

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