

Cooperative learning methods in mathematics education – 1.5 year experience from teachers’ perspective

Tünde Berta^a, Miklós Hoffmann^b

^aSelye János University, Komarno, Slovakia
bertat@ujssk.sk

^bEszterházy Károly University, Eger, Hungary
hoffmann.miklos@uni-eszterhazy.hu

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Abstract

Inclusive education and inclusive learning environment have become a major issue in Hungarian schools in Slovakia in the last decade. The number of underprivileged students with marginalised social background has risen tremendously. The primary questions of education including the provision of a proper learning environment in heterogeneous classes, the tackling of status problems among students have become inevitable. The introduction of the Complex Instruction Methodology (CIP) into the education process created an opportunity for teachers to work with heterogeneous groups in classes. Mathematics by definition creates heterogeneous groups in schools as due to large knowledge gaps among students the differentiation of work and the cooperation of students is extremely difficult. The CIP method is a special group work designed for heterogeneous groups which could provide enormous help for the work of the teachers. In the current work we would like to present the adaptation process of the CIP method in two Hungarian schools in Slovakia. By conducting a series of interviews with teachers we are going to analyse the efficiency of the CIP method in cooperative mathematics classes.

Keywords: Complex Instruction Program, problem solving, cooperative math-

ematics, inclusive teaching, group work, heterogeneous student group

MSC: 97D20

1. Introduction

Teaching even in its simplest form is one the most complex tasks. The teacher has to adapt to classes numbering 20 to 30 people, to class syllabuses and to individual need of students as well. The usual teaching methods are not in compliance with current expectations of the society, they have changed a lot in the past 15 years. The labour market presents a demand for young people who are innovative and adaptive to the rapidly changing world. There is a widespread need for new basic skills affordable to everyone. There are new skills to be acquired: to solve problems, to look for sources needed for the task, to cooperate with each other in groups, to express their opinion, to focus on a given problem. It is an outstanding obstacle for Hungarian schools in Slovakia as the composition of the students is extremely heterogeneous. The work with heterogeneous groups of students according to knowledge and social status presents a highly demanding challenge for the teachers. The international and Slovakian studies on teaching has revealed that the unchanged system of education has not been successful. Critique has been oriented both towards the content and the methodology of teaching. A substantial part of students do not have sufficient level of development (Monitor5, Monitor9, centralised school leaving exams). The students lost their motivation, studying has become a painful experience for them. Traditional teaching methods are not sufficient for success.

There are new promising methods available, but their infiltration to the Hungarian education system in Slovakia is very poor. Due to the Slovak official state language there is a time shift until they can reach Hungarian students in Slovakia. It takes years of preparation until a new textbook or a new development reaches its target audience. The introduction of new teaching methods is a slow procedure. In the past years project methodology and cooperative learning has come to the forefront. Its adaptation Hungarian schools is similar to its adaptation in Hungary, most Hungarian teachers in Slovakia use the actual available literature in Hungary. In the study we shall focus on the adaptation of the Complex Instruction Methodology into the mathematics teaching in Slovakia: the process itself and the experiences of teachers.

2. CIP – a special cooperative learning process

Cooperative learning has become the most dynamic teaching method in Western Europe and North America. Large number of studies unveiled its efficiency in various fields of education. Cooperative learning has become a summarizing term for various methods focusing on groups, classes and schools ([1, 8, 10, 15]). Cooperative learning is a management of learning in which the acquisition of knowledge,

cognitive knowledge, social motives and skills, learning motives are parallel in time and equal in their status. During cooperative learning the tasks are organised in such a way that students cannot cope with them individually, there is an essential need for constructive cooperation. The society building is not achieved by separate tools, but it is inherently built into the process [7].

The provision of equal chance to each student has become more important. The teaching method should take into account both the needs of elite students and of students with slower and lower achievements, they should have a chance to converge to students with higher achievements. It has become a major obstacle to teachers. In Hungarian schools in Slovakia this problem has become even more eminent, the share of students with disadvantageous social background has been rising in the past decades. The number of parents choosing Slovak schools for their children has been rising as well due to the fact that majority schools with Slovak language of education have better social ratios, thus enhancing the assimilation of minorities in Slovakia. When looking for plausible solutions our attention has been drawn to the Complex Instruction Programme, which has been successfully adapted in Hungary since 2000, first at the school IV. Béla Elementary School by Emese K. Nagy and her colleagues [8]. Based on their experience, a complex system called Complex Basic Programme has been developed in Eszterházy Károly University in 2016, and has been introduced to several Hungarian primary schools since 2018 [9, 11, 12].

The Complex Instruction Programme developed at the Stanford University provides an excellent opportunity for schools and teachers to create an inclusive space for students. The founding scientists of the programme assumed that the social structure of a given class could be transformed by the teachers implying the change in the environment of education which could lead to a modified learning environment for students which is most adaptable to their individual skills and needs and provides an environment for tackling status problems in classes.

The main goal of the programme was to create an equal opportunity learning environment in which access to learning and to teaching materials is equally provided for students. The programme has been designed so that teachers would have tools and methods for tackling the heterogeneity of linguistic and cultural background of students. The primary idea has been formulated that each student is capable of acquiring a higher level of knowledge once the proper conditions have been set for learning. It has been a guiding principle that the cooperation among students should be based on equal status, each student should participate in the solution of selected problems and tasks. The new method is independent of special subjects and teaching materials. In addition to cooperative learning the development of an individual student has been taken into account as well ([2, 8]).

Cooperative learning requires a different approach to the teaching planning process as well a different attitude of the teachers. The classic, in our region overruling frontal teaching method puts the teacher in the forefront, his knowledge and methods are superior. In classes using cooperative learning methods the activities of students are prior, the teacher's role is modified: helping and organising is required

from teachers. The CIP method is independent of specific teaching subjects, in addition to its ability to develop competencies it could be effectively used in individual development and work with talented students as well.

3. The introduction of CIP method in Hungarian schools in Slovakia

The cross-border project called KIP ON LEARNING – Schools in a changing world – Inclusive, innovative and reflexive teaching and learning – cross border exchange of know-how was launched in September 2017 supported by Interreg V-A Slovakia Hungary Cross Border Cooperation Programme.¹ The main objective of the project has been the introduction of CIP method in two Hungarian elementary schools in Slovakia: Feszty Elementary School in Hurbanovo (Ógyallai Feszty Árpád Magyar tanítási Nyelvű Alapiskola) and in Helmeczy Mihály Elementary School in Kráľovský Chlmec (Királyhalmeci Helmeczy Mihály Magyar Tanítási Nyelvű Alapiskola). The two schools are similar in number of students and in social status of students, one is in Western Slovakia the other in Eastern Slovakia. The number of students is approximately 300 with a large share of students from socially marginalized groups (30–35%) and Roma pupils (appr. 25%).

The CIP method has been adapted in these two elementary schools. The preparation process included purchase of equipment and surveys in both schools. The introduction of CIP methodology started in January 2018. All the teachers from both schools (60 teachers) participated at the CIP training course (60 hour training) which was followed by tutoring until the end of the project. The teachers started developing their own CIP materials after the training. The students were prepared for the new methodology, sociometric analysis was made in order to divide students into groups within classes. The teachers were acquainted with the CIP methodology in the first semester, with the help of tutors they prepared its adaptation to the education system of Slovakia. The teachers started using the method in their classes starting from the 2018/19 academic year.

The sustainability period for the project is 5 years, CIP classes were held until the closures due to the COVID-19 pandemics in 2020. The effects and effectiveness of the new methodology are analysed by continuous surveys, where several indicators are monitored: social and affective factors, number of absences, change in the status of students etc.

4. CIP learning process and the social competences

Research focusing on innovative teaching methods including cooperative learning has shown numerous accomplishments. The primary goal of the new method is the

¹Project number: SKHU/1601/4.1/172.

elevation of the knowledge level of students as well as experiencing success in the school environment. Acceptance of others and respect have been key elements as well [8].

COHEN, LOTAN describe group work as: „Students are working in groups which are small enough for each member to participate in solving tasks. It is a requirement that students are able to work autonomously without direct control of the teacher.“ ([2], p. 22.)

The CIP methodology enhances the convergence of less developed students while advanced students do not need to slow down in their work. Studies have revealed that group work enhances the understanding of the theoretical part of the subject, they are less distracted, and are able to focus more when compared to classic frontal teaching ([4, 13, 14]). Students working in groups are more tolerant in accepting their fellow classmates of different origin or social status.

CIP could be successfully used in classes with different levels of knowledge, origin and language. Students can learn from each other, they serve as role models to each other, they are interconnected, dependent on each other. Joint effort brings the experience of success to the students, authentic intellectual pride could be achieved, the outcome is on a higher level when compared to individual work. Hereby comes the main slogan of the programme: We are smarter together than alone [2].

Group work with tasks requiring different levels of knowledge and skills brings students closer to cooperation, enabling the unravelling of talents in students. Students with different levels of knowledge and skill could present different problem solving strategies, which develops their strengths while acquiring new skills. The proper compilation of tasks creates an opportunity for each student to show their understanding and abilities thus students with different social backgrounds can solve tasks successfully teaching [8].

The aim of the teacher through the organisation of group work is to provide equal opportunities to each student to participate and to ensure that everyone has a skill that leads to successful solution to the problem. The teachers need to learn to tackle the differences among students in order to enhance the development of each student. The development of the teacher's skill to organise groups is a key element to the success of the new method. When compared to classical methods where teachers are more eager to get into direct involvement and control in the new method there is no need for it. It is necessary that teachers stay in the background thus enabling the individual work of students based on the previously set roles.

It is essential that teachers are able to assign their controlling role to students. The teacher stays in the background ready to get involved if necessary thus creating a space for students to make their decisions and to develop their personalities. Students acquire skills needed for individual planning and organising their learning process [6].

Each member of the group benefits from the work if tasks are not based on routine work, when it needs to be discussed, when the outcome is not visible from the very beginning [3]. Learning from more advanced students is a key element in

cognitive development as VYGOTSKY stated: "Learning initiates various inner processes, which can only work if children get into connection with each other and they work together ([17] p.90). Joint work, common discussions, interactions provide opportunity for students to cooperate irrespectively of their level of knowledge and their rank in the class.

5. Cooperativ learning and mathematics – mathematics in CIP

There are many benefits coming from collaboration on math lessons in the classroom. Education is not equitably accessible to all students. Collaborative learning could contribute to closing the achievement gap among students and to reach greater success in mathematics. Learning by cooperative and problem-based approach students at elementary schools could get a more detailed impression on higher-level math. Students often believe that success in math is based on memorization. In addition to basic mechanics of solving problems it is of high importance that students are able to formulate and interpret more complex problems, and are able to work in groups while managing problem solving strategies. This process makes mathematics such an interesting subject. Cooperative problem solving motivates students more and could introduce them into further careers in mathematics [5].

Cooperative problem-based learning enhances the use of different abilities and could lead to mathematical growth. The cooperation develops interpersonal skills, makes conflict resolution easier and gives students some leadership experience. Working on well designed tasks provides students with common goals, sharing ideas connects people. Students can immerse the beauty and the fun in mathematics. Teachers can use cooperative learning activities in order to help students find connections between the concrete and abstract level of instruction through peer interactions and properly designed activities. Cooperative learning can contribute to the promotion of classroom discourse and oral language development [5, 7].

In Hungary a complex mathematical programme based on CIP methodology has been elaborated, called Logical Basic Program. The main goal of the basic program focuses on the change of the approach to mathematics teaching including motivation, experience based learning and development. The skills and knowledge of students should be impacted by by playing games and using game-structures, new approaches, promoting enactive and visual representation, positive reassuring environment enhancing creativity taking into consideration the level of students' progress in mathematics. Theoretical works of Zoltán Dienes, Tamás Varga and Jerome Bruner and problem and research based theories have supported this approach.

Why does the CIP method work on math lessons? First, students are more willing to solve challenging problems as a group. Second, students are often able to explain things to each other in ways that make more sense than the teacher's origi-

nal explanation. Third, students are more willing to ask questions and take risks in small groups. Fourth, students learn more when they invest in math discourse. It is of high importance teachers use flexible grouping throughout the school year so that each student is challenged appropriately and the rotation of the roles is supported. When classrooms achieve this balance, all students have the opportunity to learn within their zone of proximal development [17].

6. The experiences of teachers with CIP – analysis of interviews with teachers

We have conducted deep interviews with teachers to survey their experiences while using the new CIP method. The participating schools are mid-size involving 2 mathematics teachers, all 4 teachers have been interviewed.

Mapping the experiences of teachers with the introduction of the new teaching method was the main goal of the interviews. The interviews included the teachers' perception of the method as well as its potential to their professional development.

The interviews focused on 4 topics.

1. The first topic included the teacher's motivation, what was their motive for enlarging the scale of used methods beyond classical frontal teaching. The main motivation described by teachers promoted the involvement of those students into mathematics learning who were less interested in the subject. Bringing new motivation for students has been mentioned as well. This has been the hardest part of the education process. Students were described as having low levels of motivation, curriculum described as badly designed, useful textbooks missing from the market, deepening the gap of the level of knowledge among students as well as of their social status. Hungarian schools in Slovakia have a higher share of Roma students which is characterised by strong backlash in the level of knowledge as well as in social status of families. The involvement of Roma students into mathematics learning has been a painful experience. The new CIP method presented an emerging possibility to involve these students into education.

The improvement of the attitude of students during the classes has been mentioned often. The new method to be adapted in these schools should have been able to be inserted into the educational system. International experience with the CIP method helped the teachers' orientation and decision.

2. The second topic included the teachers' experiences on application of CIP into their classes. The questions focused on the behaviour of students during the classes, on changes in social interactions and in mathematics learning. Which competencies in mathematics could be developed most and what change could be induced in the approach of students.

All teachers involved used CIP in classes for exercising and for repetition, the new method was not used for the acquisition of new knowledge. During the interviews the teachers revealed their fears that the essence of mathematics knowledge could be lost during the cooperative classes. An assumption that less developed students would refrain from works was highlighted by the teachers. The teachers assumed that in heterogeneous groups only talented students would follow the course of mathematics classes while all the other students would emerge only as observers.

The perception of the new method has changed during the course of its adaptation. In the first period when both teachers and students were getting familiar with the new method the original assumptions were fulfilled but later the perception has changed. It is still evident that new tasks are solved by more talented students, but with the acquisition of new roles used in the CIP method all students could contribute to the outcome. The most imminent change perceived by the teachers was the enhanced active communication within the groups.

The ability of students to understand texts and solve problems was on a low level (textbooks used on the first stage of education in elementary schools do not encourage the development of these skills. Common analysis of problems and their common solution contributed to the development of these skills in a visible manner. There has been a perceivable change.

The most visible change in the long run while using the new method was the fact that students became more open in classical classes as well, they asked more questions and felt encouraged to participate in debates, the behaviour of students and their attention to classes improved as well. There were issues which could not be successfully implemented, the cyclic rotation of roles within the groups posed difficulties. Presenting the outcomes of the works has always been difficult for students and not only for those with lower level of knowledge and skills. There were students refusing to take that part, teachers were not pushing hard to do so in order to maintain the functionality of the groups. Difference in the knowledge of mathematics was not perceived with use of the CIP method, at least it could not be attached to the use of CIP. One year of experience was not enough for its perception. There has been a positive change however in the attitude of students towards problem solving, mathematical text analysing which could be connected to the use of CIP.

3. The third topic analysed was oriented towards the impact of CIP on the work of mathematics teachers in participating schools. The first thing mentioned by the teachers was the change of used routines, the shift from their comfort zone. The importance of CIP in their education was characterised by the process of the acquisition of a new method by the use of which they could depict the importance and the impact of mathematics in everyday life. The tasks selected by the teachers presented an everyday life case, formulated as an open question. The existing mathematical knowledge was made to be used in a non-conventional environment for the students. The attention paid by the teachers, the evaluation process and the self esteem of students has been outlined as well. There were teachers admitting

that observation and evaluation was missing from their previous work, it was the use of CIP that drew their attention to the importance of these elements. The method was perceived as successful for less developed students whose self esteem and motivation skyrocketed with the use of CIP.

The formulation of groups was questioned by the teachers. There were teachers using the proper method in heterogeneous group formation, but there were several teachers who disagreed, claiming that more homogeneous groups would enhance the solution of more complex mathematical problems.

Teachers who used the proper CIP method argued that cooperative learning often works best if the team members are not of the same level in mathematics. According to their argumentation the more capable students are advancing by teaching the concept while others are advancing by engaging with the problem and wrestling with the solution.

None of the teachers said that CIP could be used for effective talent management in heterogeneous groups, not even with the use of individual tasks. Individual tasks at the end of classes due to time pressure were poorly performed, often even neglected thus their function was completely lost.

The long preparation of CIP classes has been reported as the harshest drawback of the CIP method. It is hard to create innovative tasks for group work. Social sciences provide a more fruitful environment for the use of CIP classes. Drama pedagogy, music, arts are not applicable to mathematics. The types of tasks for group work start repeating after a certain amount of time. The most important factor for the use of CIP in mathematics teaching is the enhanced motivation of students for the subject. It brings new variety into monotony.

4. The last area of questions focused on the training and tutoring. Teachers expressed their satisfaction with the initial training, its content and source as well. The importance of tutoring was strengthened by the responses of the teachers. They did not perceive it as a burden, rather as a collegial help. It created a positive environment among teachers to share their experiences, difficulties and successes. The visiting of classes by the mentors was highly appreciated especially with the following consultations. The teachers would like to be in contact with their mentors in the long run. More class syllabuses are needed for the sustainability of the method in schools which are in line with the requirements in Slovakia [16]. Altogether 600 class syllabuses were prepared during the 24 months of the project, but the share of mathematics syllabuses is low. A collection of Great ideas for group work for each grade would be highly appreciated. In the management the teachers proposed that in class management double classes using CIP methodology would contribute to the success and efficiency of the new method.

7. Conclusion – experiences from the interviews

The introduction of CIP methodology into the teaching system in two Hungarian schools in Slovakia was successful. According to the teachers the method could

and should be used in education. The new method enhances better understanding of mathematics, special vocabulary is acquired by students and used in active debates. The development of problem solving and logical thinking is visible even on classical frontal classes. The most important improvement could be perceived in the behaviour of students during classes, their activity level has been visibly rising after one year of experience. Continuous mentoring is a key factor to the efficiency of teachers' work. The mentoring method should be considered in the adaptation process of other methods, starting freshman teachers should be involved in tutoring on a larger systematic level. CIP found its place in the education system of Slovakia, the penetration of the method into the teaching process of other schools is highly recommended.

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