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Online Collaborative Discourse as Formative Feedback for the Improvement of the Achievements of Students with Difficulties in Mathematics in the Seventh Grade in the Urban Arab Sector

Abstract

The changes in pedagogical academic terms and the integration of technology in the schools did not change much of the nature of the teaching of the subject of mathematics, especially for students with difficulties. Classroom teaching has remained frontal and traditional, where the teacher is the main source of knowledge, and the learner receives the information. In mathematics, the inculcation of knowledge in this format makes it easier for the teacher since it allows the teacher to convey the information widely and rapidly. The transmission of the information in this manner enables the teacher to represent knowledge in the way easiest for her and preferred by her, without the consideration of the learner's preferences. Good students can follow the teachers, and sometimes with a little help from the parents they can surmount the difficulties, but students with difficulties very quickly fall into the cracks, and feel they are foreigners in the mathematics lessons. One of the main challenges in teaching mathematics to students with difficulties is to actively involve them in the building of mathematical knowledge.

The use of digital environments has become an essential part of learning in the domain of mathematical knowledge. Current standard digital environments in mathematics nowadays are GeoGebra and Desmos. The environments offer two digital spaces, the first dedicated to the field of algebra and the second to the field of geometry. Both environments allow the immediate and rapid transition between the various mathematical representations.

The online mathematical discourse is a model of collaborative learning that is based on the sociocultural theory of Lev Vygotsky, which holds that learning is a social process through which the learner develops abilities and high cognitive functions. Social reciprocal relationships and mediation are two basic elements in developing high mental functions, such as perception, attention, memory, and thinking (Ilam, 2003). Collaborative mathematical discourse that occurs through digital learning environments is rich in mental representations that enable the mediation of the learning material dynamically and tangibly. In research, the model of the online collaborative mathematical discourse includes a method of interactive activities:

- inquiry activity for the learner's life,
- dynamic transition between the different mathematical representations,
- sharing of the knowledge and ideas for possible solutions,
- carrying out synchronous and asynchronous tasks.

Every student shares his manner of solution with the members of his group through discourse, thus exposing them to different levels and forms of representation. Participation in the group allows its members to develop their understanding at a pace suited to them and according to their ability.

This research study focuses on the influence of online collaborative discourse on students with difficulties in the field of knowledge of mathematics and learning achievements. A central assumption of the present research study is that the collaborative mathematical discourse based on digital environments advances students with difficulties in academic and achievement terms and increases the effectiveness of the teacher's work. Accordingly, the research study attempts to define the characteristics of the online collaborative discourse and examine its influence on the students' achievements, the perception of self-efficacy, the motivation to learn mathematics, and the change in the learning strategies.

To further the depth of the analysis of the data, it was decided to hold the research study according to the quantitative-qualitative approach. In the research process based on the quasi-experimental method, various mixed methods research techniques were used to obtain a consistent and comprehensive answer to the research questions. In the framework of the research study, two state middle schools of equal socioeconomic status and similar technological infrastructure were chosen. From the two schools, a group of students with difficulties in mathematics was chosen after a mapping test that was held at the start of the process. The students were divided into a quasi-experimental group and a control group of students with difficulties who did not join the quasi-experiment. At the end of the research study, a comparison was performed between the two groups. As background for the data collection, a process was performed to analyze the interviews that were held with the teachers. The data analysis facilitated the understanding of the process of the development of the student's learning abilities, the identification of the types of difficulties among them, as well as the ways of thinking and the quality of the process of solution.

The collection of the data in the schools was performed during the whole school year 2020-2021 (the school year in Israel begins in September and ends in June). Twelve mathematics teachers (Six teachers that participated in the quasi-experiment and six teachers were on the control group) and 30 seventh-grade students from two middle schools, students with difficulties in mathematics that participated in the quasi-experiment, and another 28 seventh-grade students from two middle schools, students with difficulties who did not participate in the research study (control group). The students were examined through quantitative research instruments – attitudes questionnaire, mapping test, and summative test. The questionnaire examined three elements: self-efficacy, learning strategies, and intrinsic motivation. The mapping test and the summative test were intended to map the students' level in terms of achievement and the way of building the process of solution. Between the mapping test and the summative test, the students participated in discourse-based mathematical activities in digital environments in small groups with the teacher's accompaniment. The transcription of some of the lessons enabled us to learn about their information behavior and the solution process of a mathematical solving problem. The staff of teachers, which underwent special training for the participation in the experiment, was examined using a quantitative instrument, a questionnaire that examines the mathematics teachers' attitudes regarding the effectiveness of the use of the online environment as a means that increases the effectiveness of their work and the learning dimensions in the learner with difficulties, and a qualitative instrument – structured interviews, to learn about the effectiveness/ difficulties that were when implementing the teaching methods in this field.

The analysis of the research findings indicated that the integration of online collaborative discourse as an essential part of the curriculum promoted students with difficulties, in cognitive academic terms and emotional social terms. The online collaborative mathematical discourse advanced students in terms of achievement so that the achievements in the subject of mathematics rose significantly. In social-emotional terms, the intrinsic motivation and self-efficacy among students with difficulties also improved significantly. The online collaborative mathematical discourse supported and improved learning strategies and coping with memory problems. In cognitive terms, the availability of technology is one of the ways that we can use to provide a solution for students with difficulties by reducing the load from the mental burden; namely, the difficulties in active memory and long-term memory influence the students' ability to solve problems and to examine thinking processes. The reduction of a load of complicated calculations by using technologies and the transfer of the

mental load – offloading – from the person to a tool, encourage the performance of high-thinking processes (Solomon, 2000). In addition, visual representations in learning advanced learning both in terms of memory and in terms of understanding (Mayer, 2009). The visual-motor experience with objects learned in the outside reality is important for students because children build their knowledge structures as a result of concrete experiences. Furthermore, the qualitative analysis of the teachers' interviews emphasizes that the program's success depends on the manner and degree of the teachers' exposure to the types of the discourse, the components of the discourse, and the types of the learners' difficulties and mediation strategies that improve the learners' understanding. The teacher's understanding of the importance of the discourse and its implementation in the correct way in the classroom significantly advances students with difficulties in mathematics. The research findings support the perception of the proposed model, in which the teachers who integrate online collaborative mathematical discourse into their teaching are more effective in their work with students with difficulties and the students who participate in discourse develop academic and achievement abilities and have higher-order mathematical abilities.

Therefore, it is believed that the Israeli education system must integrate online mathematical discourse into the mathematical curriculum as an essential part that includes mathematical problems from the learner's real world and mathematical activities that have the potential of different representations. In addition, the research study recommends broadening the scope of online collaborative teaching to include all students with difficulties, a greater number of teachers, and the other study levels in the school teaching system in the middle school.