18/3 (2020), 111-121
DOI: 10.5485/TMCS.2020.0477
tmcs@science.unideb.hu
http://tmcs.math.unideb.hu

Teaching
Mathematics and
Computer Science

Mapping students' motivation in a problem-oriented mathematics classroom

EMŐKE BÁRÓ

Abstract. This research focuses on mapping students' motivation by implementing problem-solving activities, namely how the problem-oriented approach affects the students' commitment, motivation, and attitude to learning. As a practicing teacher, the author faced difficulties with motivation and sought to improve her practice in the form of action research as described in this paper. Based on the literature, the author describes sources of motivation as task interest, social environment, opportunity to discover, knowing why, using objects, and helping others. The author discusses the effect of problem-oriented teaching on the motivation of 7th-grade students. In this paper, the results of two lessons are presented.

Key words and phrases: motivation, problem-oriented activity.

MSC Subject Classification: 97C20, 97D40, 97D50, 97D60.

Introduction

In recent years, many researchers report that pupils' interest in mathematics has been decreasing. Social pressures were obvious in students' interview responses that it could be not “cool” or “popular” to be good at math (Sullivan, Tobias, & McDonough, 2006). The personal experience of the author of this paper is similar. Many times the author has found that when the students hear the word “math” they react negatively: “alas math”. As a math teacher, the author feels it is her responsibility to change something about this situation. The author agrees that “motivation is the key to enhancing learning (Middleton & Midgley, 2002) and she wants to understand what motivates her students. Since the roots of the decline in the mathematical interest of young people are to be found mainly in the methods of teaching this subject, therefore, this research focuses on mapping students’ motivation by implementing problem-solving activities.

Literature review

The basic principles of teaching and learning by Pólya (1981) are the ones that we can rely on and contain the principle of best motivation besides the principle of active learning and consecutive phases. Pólya also emphasizes the connection between motivation and problems. “The interest of the material to be learned should be the best stimulus to learning and the pleasure of intensive mental activity should be the best reward for such activity.” (Pólya, 1981, p.103)

In the literature, there are multiple definitions of motivation. Motivation can be described as the student’s willingness, need, or desire to participate in and be successful in the learning process (Yunus & Ali, 2008). One can define motivation as an individual’s desire to act in specific, personal ways (Weiner, 1992). Motivation is often characterized as either intrinsic or extrinsic (Corpus, McClintic-Gilbert, & Hayenga, 2009). J. Irvine (2015) claims that using problems fosters and supports student motivation to do mathematics. Moreover, Walter and Hart (2009) describe sources of motivation as (1) task interest, (2) social environment, (3) opportunity to discover, (4) knowing why, (5) using objects, and (6) helping others, see also (Francisco, 2005). Later the author refers to these items as Walter & Hart’s factors of motivation.

In mathematics education, a problem is a task that requires the application of an unknown combination of tools or a novel combination of several known tools to solve a problem, and is not obvious to the problem solver (Claus, 1989). Csíkos et al. define problem-oriented learning in mathematics as requiring students to analyse mathematical problem situations, to critically approach their own and their peers’ minds, and they must learn to explain and justify their reasoning (Kelemen, Csíkos, & Steklács, 2005). This formulation is tied to Walter and Hart's motivational factors in several aspects. However, for the practicing teacher, the question is open as to how Walter and Hart's factors can be related to problem solving, i.e., what is behind the general formulation of Pólya's statement cited above.

Research question

The author believes that the problem-oriented approach helps students' motivation, and searches for evidence in her teaching practice, so the following research question was formulated. *How can the problem-oriented approach affect the students' commitment, motivation, and attitude to learning?*

The author contributes to answering this question in the form of action research (Koshy, 2005) with a qualitative analysis of a lesson. The curriculum was implemented in two classes in the same school, according to the same lesson plan on December 18, 2018. In the lesson plan, besides the problem-oriented approach, Walter and Hart's factors appeared also.

The circumstances of the experiment

Participants

The participants of the research are the two 7th grade classes of the Balázs Orbán Primary School in Odorheiu Secuiesc, Romania, in which a total of 50 students study: Class A (26 students, 14 of them girls), Class B (24 students, 8 of them girls). The language of instruction is Hungarian, which is the mother language of the students.

Both classes were formed seven years before the research. In the fifth and sixth grades, both classes were taught by the same person, and the author of this paper ("the teacher" in what follows) began teaching them from the seventh grade. Class A is the "better" class in terms of grades in math, but based on the teacher's impression, class B students have a better disposition towards mathematics.

Method

The lessons were held as part of a larger research project in which researchers at the University of Debrecen, Hungary studied problem solving in school settings (Kovács & Kónya, 2019), (Kónya & Kovács, 2018). Walter and Hart's factors formed the main guideline for planning lessons selected from the curriculum. Both class sessions were videotaped. All videos were transcribed. Verbatim transcripts, nonverbal communications, remarks, and observations were linked with video time codes and a time-table was also registered to measure the time spent on different activities. Concerning the methodology for creating the time-line, see (Herendiné-Kónya & Földesi, 2016). Teacher's reflection, students' work, pictures of the blackboard, and students` evaluation cards were available for analysis. The interpretation of the collected data was performed in agreement with the leaders of the research project.

Task

The lesson plan consists of three main parts, dealing with three problems. In this paper, the author deals with only one problem in detail. This is the "folding paper strips" problem: "Take a long strip of paper and fold it in half from right to left. When it is opened, it has one crease and two rectangles. Fold the paper in half two times from right to left. When it is opened, it has three creases, four rectangles. After *n* folding operations, how many rectangles are formed, and how many creases are formed?" (Mason, Burton, & Stacey, 2010). Fritzlar (2006) studies decision-making situations in the study of sensitivity to complexity, during which he presents a similar problem (folding problem).

Data collection

Based on the transcripts of both lessons, the author examined students' motivation based on the occurrence of Walter and Hart's factors. The author collected the indicators listed in Table 1 for the factors (1)-(4). The "helping others" factor (5) was realized through the Think-Pair-Share (TPS) cooperative method (Kagan, 1994). There is no direct recording of pair discussions. In this respect, the conclusion is based on the notes taken by the teacher directly after the lessons. Moreover, students could use the paper strips as a tool in solving the tasks, which supports the "using object" factor (6).

Source of motivation	Indicator
(1) task interest	intentional and emotional manifestations students' perseverance creative problem-posing activity
(2) social environment	classroom discussion (no. of participated students)
(3) opportunity to discover	formulation of rules (no. of formulated rules and examples)
(4) knowing why	explanation, argumentation (appearance of proof-like activities)

Table 1. Sources of motivation and their indicators

Results and discussion

The lessons in Romania are 50 minutes long, but in this research, only the effective part of the lessons was considered. (I.e., the author ignored classroom organization at the beginning and the end of the lessons as well as some unexpected interruptions.) The time-line of the performed lessons (Fig. 1) shows that in both cases, classroom discussions are about half of the lesson, while the teacher's intervention is much less. All, except two students, were involved in the individual and pair work. The structure of time distribution in the two classes is similar, and a small difference can be observed between the two classes. This is due to the fact that class B asked for additional time during individual work.

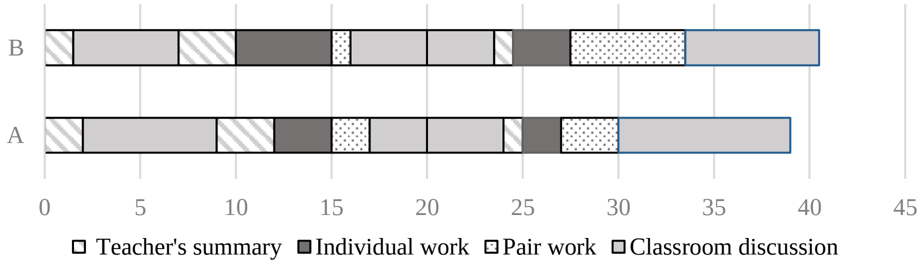


*Figure 1.*Time-line of the lessons

Task interest – Intentional and emotional manifestation

Statements such as “I have here too, I'll give you paper.”, “Should I write this, or should we just say it?”, suggest that the student is watching, is interested in what is happening, wanting to facilitate the course of the lesson. Interventions like “With colour?”; “Can another be also folded?”; “Then we have to leave three?”; “Only need to fold four times?” suggest that the student is ready for the task, waiting for the rest of the task, interested in what to do next. All the cited manifestations are closely related to the “using object” factor, which multiplied the signs for emotional engagement compared to regular lessons.

Task interest – Student perseverance

“…Let’s say how we calculated?”; “I know one more solution.” type sentences indicate that students are engaged in the actual task, students try and try again until the learning goal is attained. The request “Moment, not yet (project the result)” suggests that the student wants to solve the task alone first, he does not want to see the result, only after he has finished solving his own. Also, during the pair work, several students ask the teacher to check separately for their solution, whether she considers it correct, which means that they worked, did the tasks.

Task interest – Creative problem-posing activity

According to Silver (1994), problem posing is a mean of improving students’ disposition towards mathematics: “…personal interest is not the sole motivation for posing problems. Within a classroom community, students could be encouraged to pose problems that others in the class might find interesting or novel” (p. 25). The students were asked to write their math problems using the paper strip after four foldings as the starting situation. In the problem-formulation phase, the author observed that students ‘immersed’ themselves in the situation and invented creative problems, for example:

S1: There was a cheese once. One day they bought it in the store and took it home, and ate half of it. Then the next day they ate half again. And the third day again in half and still remained small. In how many days did they eat it? [After the teacher points out that it would be impossible, he modifies the question.] We just do not say that on the third day and the fourth, but the next day [n^{th} day]. Or how much cheese is left [after the n^{th} day]?

S2: There was a lake. That doubled every day. It has grown, and grown. And how many times did it become after four days?

S3: There is a fence that is 16 centimetres, how many centimetres is the length of a plank if fold lines correspondes to the edge of the plank?

Helping others – TPS

Based on the teacher's reflection, the work in pairs was implemented effectively in class. The next episodes show that it is an essential task for the teacher to monitor the pair work. There were a couple in both classes where there was no agreement among the students. In both cases, it was a student who got better and another who got lower marks from math. In one class, there was a minor dispute between the two students, and in the other class, they quickly agreed. In both cases, by the end of the pair discussion, the wrong solution was accepted by the couples, as the "good student" managed to convince his partner that he was right. During the class discussion, the teacher clarified the situation, and when the right solution came out, one of the students of the couple remarked, "Well, do you see that I was right?". This was not only an opportunity for the weaker student to take an active part in the math class, but it could also be a satisfaction, a motivation that maybe next time it might be worth joining the class because he has good ideas and solutions.

Social Environment – Classroom discussion

Thanks to the applied cooperative technique, the atmosphere of the classroom discussions was pleasant. The TPS also helped the motivation by allowing the students to engage in the joint conversation in a way that they already had prior experience of the problem in the Think and Pair phases.

The fact that the teacher is expecting not just one answer, but more, and even all may be right ones, can give the student freedom and more opportunities to manifest. We got a right solution, "I know one more." came the next idea—a similar observation in problem-posing activity.

Based on Table 2, it appears that at least half of the students in both classes intervened (class A: 50%, Class B: 66%), which also confirms the previous teacher's remark that class

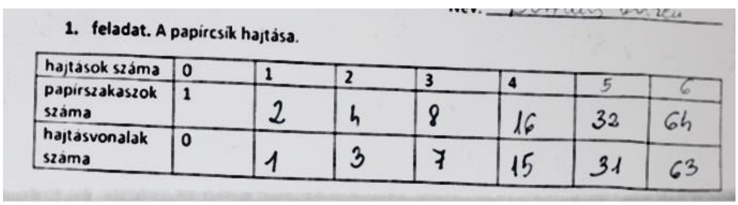
B is more active in math classes. The students speak a total of 86 and 81 times, respectively, in 43 and 43,5 minutes, suggesting that productive classroom discussion evolved.

Activity	Number of students		Number of speeches of students	
	Class A	Class B	Class A	Class B
Task 1	10	10	24	24
Paper strips	11	10	26	37
Task 3	9	12	36	20
Lesson Total (*)	13	16	86	81

Table 2. Number of students who spoke frontally on the three activities. * Lesson Total: Data specific to the lesson as a whole

Opportunity to discover – Formulation of rules

Students had the opportunity to think independently, work individually as part of TPS Think, and then discuss their plans and ideas in the TPS Pair phase.


1. feladat. A papírcsík hajtása.

hajtások száma	0	1	2	3	4	5	6
papírszakaszok száma	1	2	4	8	16	32	64
hajtásvonalak száma	0	1	3	7	15	31	63

Figure 2. Fragment from student’s worksheet – number of folds, sections and fold lines

To the teacher’s question, “What regularity was thought to be discovered in the series?” there were several different, correct answers for the strips of paper.

S4: The number of sections always doubles and the number of fold lines is 1 less.

S5: Same at the top, but at the bottom the difference always doubles.

S2: Bottom sequence would have come out to double the number and add one.

S6: That the number is with itself if we add it up.

S7: The sum of the top and bottom row numbers is equal to the number in the bottom row.

S8: The powers of two!

Knowing why – Explanation, argumentation

Not only did the students give several different correct answers to each question, but they also explained them. They correctly explained why the number of paper sections doubled. Not only were they interested in the result, but also in the process that resulted in the obtained number. For example, a strip of paper (using objects) helped them in this mapping process, which they used to explore the process, solve the problem, and then reflect on the solution.

Teacher: Let's discuss why these regularities happened?

S9: …what has already been folded is doubled (explains the change of the number of segments)

S10: If I have a strip once folded, I fold again, so one fold line appears on each section. It is the way I get the next number.

Conclusion

The action research presented here supports results by Walter and Hart, namely it detects the positive impacts of each of Walter and Hart's factors on students' motivations. These factors can be included naturally into lessons planned in the problem-oriented approach. The author finds that students' disposition towards mathematics can be enhanced through a problem-oriented approach, deliberately utilizing Walter and Hart's factors. This conclusion is supported by the "evaluation cards" on which most of the students (class A: 73% and class B: 83%) reported positive emotions. We can conclude that problem solving is an excellent way to support and increase the student's commitment and motivation, assuming that we choose good learning and teaching methods, such as providing appropriate tools, and we create a good classroom climate. The chief limitation of my action research is that it is not possible to generalize from the examined population to others.

References

Claus, H. J. (1989). *Einführung in die Didaktik der Mathematik.* Darmstadt: Wissenschaftliches Buchgesellschaft.

Corpus, J., McClintic-Gilbert, M., & Hayenga, A. (2009). Within-year changes in children's intrinsic and extrinsic motivational orientations: Contextual predictors and academic outcomes. *Contemporary Educational Psychology, 34*, 154–166.

Francisco, J. M. (2005). Students' reflections on their learning experiences: lessons from a longitudinal study on the development of mathematical ideas and reasoning. *The Journal of Mathematical Behavior, 24(1)*, 51-71.

Fritzlar, T. (2006). Sensitivity to complexity—an important prerequisite of problem solving mathematics teaching. *Zentralblatt für Didaktik der Mathematik, 38*, 436–444.

Herendiné-Kónya, E., & Földesi, K. (2016). On observation of problem solving in a Swedish and a Hungarian 5th year class. In T. In: Fritzlar, D. Aßmus , K. Bräuning, A. Kuzle, & B. Rott *(Eds.) Problem solving in mathematics education. Proceedings of the 2015 joint conference of ProMath and the GDM working group on problem solving.* (pp. 123-136). Münster: WTM.

Irvine, J. (2015). Problem Solving as Motivation in Mathematics: Just in Time Teaching. *Journal of Mathematical Sciences, 2*, 106-117.

Kagan, S. (1994). *Cooperative learning.* San Juan Capistrano: CA: Kagan Cooperative Learning.

Kelemen, R., Csíkos, C., & Steklács, J. (2005). *A matematikai problémamegoldást kísérő metakognitív stratégiák vizsgálata a hangosan gondolkodtatás és a videomegfigyelés eszközeivel.* Magyar Pedagógia.

Kónya, E., & Kovács, Z. (2018). Let's explore the solution: Look for pattern! In B. Maj-Tatsis, K. Tatsis, & E. Swoboda, *Mathematics In The Real World* (pp. 136-147). Rzeszów, Poland: Wydawnictwo Uniwersytetu Rzeszowskiego.

Koshy, V. (2005). *Action Research for Improving Practice: A Practical Guide.* . Thousand Oaks, CA: SAGE Publications.

Kovács, Z., & Kónya, E. (2019). Implementing problem solving in mathematics classes. In A. Kuzle, I. Gebel, & B. Rott, *Implementation Research on Problem Solving in School*

Settings: Proceedings of the 2018 joint conference of Promath and the GDM working group on problem solving (pp. 121-128). Münster, Germany: WTM Verlag für wissenschaftliche Texte und Medien.

Mason, J., Burton, L., & Stacey, K. (2010). *Thinking Mathematically (Second edition).* Pearson.

Middleton, M., & Midgley, C. (2002). Beyond motivation: Middle school students' perceptions of press for understanding in math. *Contemporary Educational Psychology, 27(3)*, 373–391.

Pólya, G. (1981). *Mathematical discovery: On Understanding, Learning and Teaching Problem Solving (Combined edition).* John Wiley & Sons.

Silver , E. (1994). On mathematical problem posing. *For the Learning of Mathematics, 14*, 19-28.

Sullivan, P., Tobias, S., & McDonough, A. (2006). Perhaps the decision of some students not to engage in learning mathematics in school is deliberate. *Educational Studies in Mathematics,*, 62, 81–99.

Walter, J., & Hart, J. (2009). Understanding the complexities of student motivations in mathematics learning. *The Journal of Mathematical Behavior, 28*, 162-170.

Weiner, B. (1992). *Human motivation: Metaphors, theories, and research.* Newbury Park: CA: Sage.

Yunus, M., & Ali, W. (2008). Metacognition and Motivation in Mathematical Problem Solving. *The International Journal of Learning: Annual Review, 15.*, 121-132.

EMŐKE BÁRÓ

ORBAN BALÁZS ELEMENTARY SCHOOL, 535600 ODORHEIU SECUIESC, BVD. INDEPENDENTEI 35, ROMANIA

UNIVERSITY OF DEBRECEN, INSTITUTE OF MATHEMATICS, H-4002 DEBRECEN, PF. 400, HUNGARY

E-mail: baro.emoke@science.unideb.hu