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TWG08: Affect and the teaching and learning of mathematics 1298

Positive changes in affective variables: Two-round action research in Hungary and Romania

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The author of this paper is a mathematics teacher in Romania, and she is interested in students' motivation and attitude towards mathematics. Teachers face challenges in the online learning environment, such as fewer direct social interactions, one of the effects of which is a reduced possibility of motivation. In collaboration with two academic experts and another teacher from Hungary, the research group sought answers to these challenges. In two-round action research, the impact of problem-posing on motivation was investigated. Informed by the experience of the other teacher in the first round, the author redesigned the second round, with more emphasis on emotional factors. The author argues that problem-posing can be successfully adapted during online learning, and by incorporating interpersonal interactions into the problem-posing process, the reduced motivational effect observed in online learning can be compensated.

Keywords: Action research, mathematics activities, problem posing.

Introduction

The global outbreak of the COVID-19 pandemic affected almost every country and territory in the world. Due to the pandemic, lockdown and rules of social distancing have led to closures of schools in Hungary and Romania, like in most countries, decreasing social interactions in the learning process. When teachers were asked to select their top three concerns about distance learning on students, the most common answers were: students' social isolation, a decrease in student well-being, and potential learning loss. Surprisingly, educators ranked students' social needs above learning loss (Flack et al., 2020). Hattie (2008) states that social interaction within classrooms is positively associated with learning outcomes.

The pandemic is also affecting teaching methods. However, teachers cannot give up specific methods such as problem-posing and its positive effects on learning. Problem-posing positively impacts motivation, while motivation and interest have a close relationship with context personalization of students' tasks (Walkington et al., 2013). Moreover, personalization is an energizing factor, which is significant for the student's motivation (Suriakumaran et al., 2017). Our research team, two teacher-researchers (including the author) and two experts, implemented problem-posing in an online environment. The principle was to use info-communication tools that the learners and teachers were comfortable using. In this article, the author focuses on a single aspect of the problem-posing, namely its positive impact on motivation (Silver, 1994). The online learning environment reduces interpersonal relationships, so the positive effect of problem-posing on motivation in the online environment may decrease. Moreover, decreased interpersonal relationships lead to decreased motivation since interpersonal relationships in students' lives contribute to their motivation (Martin & Dowson, 2009). As a result, the importance of emotional factors through interpersonal relationships in online education should be growing, which implies our research question: *Does the increased role of emotional factors impact the context personalization and, through this, students' motivation?* The author inferred motivation using content analysis that unfolds context-personalization characteristics. An online questionnaire followed the analysis with questions on motivation.

Theoretical background

Motivation can be described as the student's willingness or desire to participate and succeed in the learning process. Weiner (1992) defines motivation as an individual's desire to act in specific, personal ways. Walter and Hart (2009) describe sources of motivation as task interest, social environment, opportunity to discover, knowing why, using objects, and helping others. Some researchers emphasize the importance of context personalization that helps to target students' out-of-school interests and experiences (Cordova & Lepper, 1996). Walkington et al. (2013) describe context personalization as an approach to learning in school. Personalized problems may make mathematics more accessible to students, they may help bring the "real world" problem solving closer to "school mathematics," and they may attract students' attention and interests to impact motivation (Boaler, 1994).

In this paper, the author uses the concept of problem posing in the following sense.

> By problem posing in mathematics education, we refer to several related types of activity that entail or support teachers and students formulating (or reformulating) and expressing a problem or task based on a particular context (which we refer to as the problem context or problem situation). (Cai & Hwang, 2020, p. 2)

Several aspects of problem-posing (PP) are thought to have meaningful relationships to student disposition toward mathematics. For example, posing offers a means of connecting mathematics to students' interests. Within a classroom community, students could be encouraged to pose problems that others in the class might find exciting or novel (Silver, 1994).

Ellerton (2013) proposes the Active Learning Framework (ALF) for PP in mathematics classes, defining four steps: 1. The teacher models an example (processing the new content) 2. Students solve problems based on model 3. Students pose problems with the same structure as model 4. Finally, the class discusses and solves problems posed by students as "My classmate's problem." This framework considers PP in classrooms an essential activity that allows students to consolidate their knowledge and think critically about it.

The affective domain is defined in many ways in educational and psychological literature. Often it is used as a broad umbrella concept that covers attitudes, beliefs, motivation, emotions, and all other noncognitive aspects of the human mind (Hannula, 2020). This paper focuses on self-concept, anxiety, motivation, perceived usefulness, and enjoyment of mathematics. Mathematical self-concept refers to one's ability to learn and perform mathematical tasks, how confident one is in learning new mathematical topics, and one's interest in mathematics (Reyes, 1984, p. 560). Mathematics anxiety is defined as a sensation of stress and apprehension that interferes with mathematics performance ability, number manipulation, and problem-solving (Richardson & Suinn, 1972). Perceived usefulness refers to how students can relate school mathematics to real-life (Reyes, 1984). Finally, the usefulness of mathematics includes liking mathematical terms, symbols, or routine counting, but liking mathematics problems as well (Aiken, 1974).

The circumstances of the action research

The challenge of action research is how to adapt the ALF model to the online environment while retaining the motivational potential of problem-posing. This question touches on all components of ALF, i.e., how to present the model problem, how to practice, how to do the problem creation, and how to process the classmate's task.

Participants

The participants of the research are four 6th grade classes from Hungary and Romania. The teachers of the two classes in Hungary are the same person. Similarly, the two classes in Romania are taught by the same mathematics teacher. 125 students participated in the experiment: 65 from School 1 (Hungary) and 60 from School 2 (Romania). The language of instruction is Hungarian in both schools, being Hungarian the students' mother language.

Method

Curricula and syllabi are different in the two countries, which led us to divide them into rounds of our action research. The first round took place in School 1 in the spring semester of 2020, while the second one in School 2 in the autumn semester of 2020. The researchers implemented the ALF method for the following curricular lessons in both schools. 1. Proportional division (two PP activities), 2. Straight and inverse proportionality (two PP activities), 3. Percentage calculation, calculation of the percentage base (one PP activity). Both rounds were organized under online teaching conditions ordered due to the viral situation. This circumstance allowed us to focus on the challenges and experiences gained from the first round and transform them into opportunities. Table 1 contains similarities and differences between the rounds in each phase of the ALF.

Table 1: Differences between the two rounds of ALF

ALF step	Round 1	Round 2
Model problem	Slideshow that the student works up at home.	Slideshow that students work on with the teacher in an online lesson.
Practice	Self-regulated learning through a presentation.	Teacher-regulated learning through a presentation in an online lesson.
Problem-posing	Homework to be sent to the teacher.	Homework to be sent to the teacher.
Classmate's problem	Based on the teacher's selection.	Based on the teacher's selection.
		Who is the problem poser?
	Homework.	Online classroom: individual work.
Evaluating the solution	By the teacher.	By the problem poser.

Round 1: The teacher prepared a slideshow with narration and timing, which included the stages of introduction and practice. Students had the opportunity to play the slideshow several times before they started the problem-posing activity. After collecting the posed problem, the teacher selects one (or two) as “My classmate’s problem” and sets as homework that are also collected.

Round 2: The teacher prepared the same slideshow, but instead of sending it out, she presented it via Google Meet lessons, where students can comment, ask, talk. Problem posing activity is homework as in Round 1, but “My classmate’s problem” is also discussed live and solved during online lessons. Solving “My classmate’s problem” was preceded by a discussion with the topic: Who is the problem poser? Why do you think that? As a new step, after revealing the problem poser’s name and solving the problem, they added the story that inspired them in the process of the PP. Solving the classmates’ problem was an individual task followed by a discussion of whether the problem poser accepts or declines the solution of the class. Through these conversations, emotional factors were given a more significant role in Round 2, letting us know each other’s stories. Essentially, it is about bringing the task to be solved emotionally close to the students, thus making them more motivated to solve it.

Collecting Data

Parts of the research material are students’ work, students’ answers to the questionnaire, video recordings of Round 2 lessons, and teachers’ reflections. All the student works were coded, taking into account the coding frame for evaluating out-of-school interest (sports, video games, pets, sports, info-communication tools, social media, food) based on Walkington et al. (2013). It was also identified two other ways (besides out-of-school-interest) that students use to express their presence in the posed problems that the author calls personal traits:

a. Student’s direct presence in the posed problem by using the first-person singular. The personalization is given by the conjugation and pronoun “Me/I” and not the activity. For example, “My favorite T-shirt was finally on discount.” In the second case, the name of the “hero” in the story coincides with the student’s name who posed the problem: “*Zsófi* does 3 km in 50 mins.”

b. Actual or happened situations: The written context refers to an event that happened lately. For example, the following problem refers to the actual Black Friday: “Peter buys a new laptop, with a 30% discount it is 1500 Ron on Black Friday. What is the laptop’s original price?”

Results

We observed two developmental aspects of affect in Round 2: the role of different emotions, values in PP, and the role of affective factors in interpersonal relationships between students, teachers.

Role of different emotions, values in problem posing

Having different emotions, values, hobbies, and interests encourages students to remark their presence (directly or indirectly) in the posed problems. These interests were discovered in many of the students’ work. They include their personal interests in their problems; this is how they express themselves and their bonding to the subject. We managed to bring the “real world” problem solving closer to “school mathematics” problem solving, which may attract students’ attention; they could be saying, “this happened to me/might have happened to me”.

The personal trait appears in 9% of all problems (Table 2), and there is no significant difference between the two schools (21% in School 1 and 14.8% in School 2; the Fischer test result is 0.12>0.05). Thus, this form of personalization follows from the PP activity itself, and the research suggests that emotional factors have little influence.

Table 2: Number of problems with the sign of a personal trait

Appearance of personalization	Problems with a sign of a personal trait	Problems with no sign of a personal trait	Sum
School 1	46	173	219
School 2	28	160	188
Sum	74	333	407

In Round 2, we observed that more personalized context appeared in the posed problems (Table 3). For example, code "out-of-school-interest" was identified in 67 cases in School 1 (30.6% of all problems), while in School 2, this number is 76 (40.4%).

Table 3: Number of problems with the sign of out-of-school interest

Appearance of personalization	Problems with the sign of out-of-school interest	Problems with no sign of out-of-school interest	Sum
School 1	67	152	219
School 2	76	112	188
Sum	143	264	407

Personal interest was more prevalent in the second round, and the difference is significant. Fischer's exact test result is $p = 0.047$; the result is significant at a significance level of 0.05. We explain the difference by the increased role of emotional factors because they felt motivated to use their out-of-school interest in the posed problems.

Role of affective factors in interpersonal relationships between students, teachers

During Round 2, students were asked to guess the author of "My classmate's problem". The following discussion was transcribed from the second online lesson.

Teacher: [sharing her screen with the posed problem] Firstly, I would like you to guess who could have written this problem?
Student 66: Mrs. Teacher, it is obviously G. (Student 82).
Student 62: This is G.
Many: Yes, G. wrote it.
Teacher: Why is it obvious that it is G? She has hens with lice?
Student 69: She has stories like this.
Student 62: She has lived on a farm.
Many: [laughing]

Teacher: G, got your hens lice, or what?
Student 82: [laughing] No, but my grandma used to have hens. That's where the idea came from.
Teacher: I love this problem.

As students talked about the possible problem posers, the teacher could join the conversation and observe their relationship. The teacher found out someone's pet's name, for example, and who had known that before. These conversations offer a social interaction between students, including the teacher, improving Walter and Hart's (2009) motivational factors such as task interest, social environment, and helping others. The teacher observed that developing the online social environment had been contributing to a more inclusive classroom atmosphere. These problems were very memorable; even a few months after the PP activities, some students fondly remembered the lessons, suggesting that they liked solving problems about G's hens.

Round 1's ALF included affective factors such as self-concept and motivation via personalization of the context. Telling and listening to classmates' problems added additional factors. Figure 2 shows that listening to a story that inspired a classmate arouses other students' interest, leading to the enjoyment of mathematics, decreasing anxiety. By telling the story that inspired the student in the process of PP, he or she would pose a more realistic problem, which can change the student's view of the usefulness of mathematics.

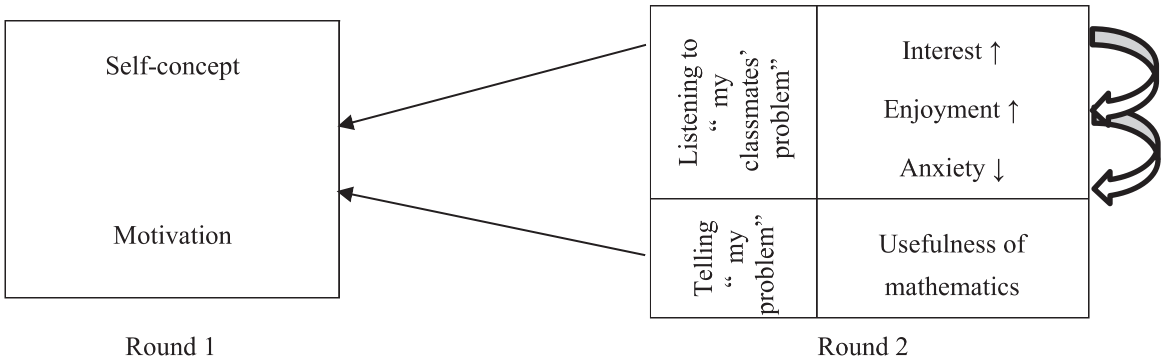

Figure 1: Affective factors added in Round 2

Knowing the background story while solving each other's problems seemed interesting to students, such as realizing that their story could have happened, which was revealed from the classroom discussions. Analysis of the answers to the questionnaire also supports this observation. At the end of the teaching unit, students were asked to answer 16 questions leaving their opinions about this new teaching-learning method. Three of them are highlighted here, I6, I8, and I9 (Table 4). We used Likert scale items with three grades according to the children's age specifics: Agree/Cannot decide/Disagree. Only definitive answers were evaluated (agree, disagree). Three items were assigned to motivation, belief, and emotion. To analyze the data statistically, contingency tables were created. The distribution of the answers is shown in Table 4.

Students enjoyed solving the classmate's problem in both schools, but the ratio of those who agreed with I9 was greater in the second round (95.7% versus 84.8%). However, the difference is not significant ($p = 0.12$). Table 4 also shows that almost 75% of students are happy to pose their problems. The author considers this fact as a sign that the adaption of the ALF paradigm was successful in both rounds. The positive answers to I8 suggest the idea that students are aware of the fact that their problems are realistic and support our finding that problem-posing positively influences students' perceptions of the relationship between school mathematics and real life. There was no significant difference between the two rounds in this respect.

Table 4: Students' responses to the three questionnaire items

	I9: I liked it when the classmate's problem was the homework.		I6: I liked to come up with my own task for math lessons.		I8: I have created tasks that can occur in real life.	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Round 1	28	5	22	8	24	4
Round 2	45	2	32	11	39	3

Conclusion

Although the participants of the two rounds were children from different countries, that could be a limitation of the study regarding the statistics, but also an advantage, which suggests a new plan for the future. The author desires to try out this method with the same students on different curricula and the same curriculum with other students; if the pandemic allows, in situ in the classroom. The author found that PP has a motivating effect in the online environment as well, and even this positive effect can be increased by including emotional factors. The author also claims that problem-posing opens up space for the expression of personality. It is an opportunity for the teacher, even in the online environment, to learn what is currently occupying the student, their hobby/circle of friends, even to conclude relationships between them. The author finds that students pose more context personalized problems by increasing emotional variables and are happier to solve their classmates' problems than with fewer affective factors. By and large, the adaption for the online learning environment went successfully. Based on the literature (Martin & Dowson, 2009) and the experiment, the author claims that more social interactions promote context-personalization, which triggers motivational factors.

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