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IMPACT OF WRITING ABOUT MATHEMATICS IN A HUMANISTIC CONTEXT ON MATHEMATICAL SELF-CONCEPT: A TWELFTH-GRADE PILOT STUDY

Abstract. As one's learning results from a complex interplay among his/her cognitive, metacognitive and affective domains, the last of which determines the global context where cognition takes place monitored and controlled by metacognition, the learning outcomes may primarily be interpreted in affective terms. Having in mind a strong positive relation between mathematical self and mathematical achievement as well as that a humanistic approach to mathematics teaching/learning would promote higher mathematical self, this study examined whether writing about mathematics in a humanistic context influences mathematical self. This question was answered by comparing mathematical self of twelfth-grade gymnasium (high-school) students who wrote their matura works on mathematical themes (N = 10) with that of their classmates who did that in other subjects (N = 72). A higher mathematical self was found for these ten students, which may be commented with »those who chose to write matura works in mathematics were simply those with higher mathematical self and the writing contributed nothing to the outcome«. The values of other control variables measured in grades 9-12 evidence that it is more likely that this finding was influenced by the treatment.
Keywords: humanistic education, mathematical self, mathematics education, matura work, upper secondary.

Introduction

Many researchers are concerned with humanistic mathematics education (see, for example, Brown, 1996) and articles published in *The Humanistic Mathematics Network Journal Online*[1]). To promote the human face of mathematics, we may use the following activities: (1) examining wrong and inadequate items from the philogenesis of mathematical knowledge; (2) demonstrating the ways of creating and testing items of this knowledge; (3) considering proving as a form of social interaction; and (4) examining the use of items of mathematical knowledge in modelling the reality (Kadijevich, 1998). Such activities not only support three groups of aims of mathematics education (utilitarian, disciplinary and personal) underlined by Niss (1996), but also cover key-activities for doing and creating mathematics such as calculate, apply, construct, play, evaluate prove, order and find exemplified by Zimmermann (2003). There is no doubt that utilizing them would not only improve the practice of teaching and professional teacher development, but also result in better learning results.

Apart from developing these activities further through making the use of other relevant sources (Singh, 1998), Tzanakis and Arcavi (2000), and the MMA Mathematics Awareness Activities[2], research may also study their empirical values in cognitive, metacognitive and affective terms. As one's learning results from a complex interplay among his/her cognitive, metacognitive and affective domains, the last of which determines the global context where cognition takes place monitored and controlled by metacognition (see, for example, Schoenfeld, 1985), such a study may primarily examine affective domain. Having in mind a positive relation between mathematical self and mathematical achievement (Kadijevich, Amit, Haapasalo & Marlewski, 2003), this study examined the following question: Does writing about mathematics in a humanistic context influence mathematical self? This question was answered by comparing the mathematical self of twelfth-grade gymnasium (high-school) students who wrote their matura works[3] on mathematical themes with that of their classmates who did so in other subjects.

Method

The study used a sample of 82 twelfth-grade students of XV Belgrade Gymnasium (high-school) who came from four classes oriented toward natural sciences and mathematics.[4] Ten of these students wrote their matura works in mathematics.

The study had a factorial design. The factor was treatment group (1 – matura work in other subject, 2 – matura work in mathematics), whereas the measured variables were: mathematical self in grades 9 and 12, mathematical knowledge in grades 9 and 10, final mark in mathematics in grades 9-12; generalized self-efficacy in grade 9, intellectual self-efficacy in grades 9 and 12, external locus of control in grade 9, non-verbal IQ in grade 9, and general school success in grades 9-11.

[1] Available at *http://www2.hmc.edu/www_common/hmnj/*
[2] See *http://www.mathforum.com/mam/*
[3] The successful defence of which evidence one's maturity to finish his/her secondary education.
[4] Although these classes comprised 123 students, the data on various variables collected in ninth grade and twelfth grade were only available for 82 of them.

Mathematical self was assessed by the scale developed by Opachich and Kadijevich (1997) comprising 29 five-grade Lykert-type items. Its alpha reliability obtained from the subjects' answers was good (.89 in grade 9 and .87 in grade 12). Mathematical knowledge in grade 9 was assessed by a test comprising 15 tasks that called for basic knowledge and skills learned in that grade. The subject's mathematical knowledge was represented by the total score obtained on the test and the alpha reliability of this measure was .79. Such a test in grade 10 comprised 13 tasks, the subject's mathematical knowledge was represented in the same way, and the alpha reliability of this measure was .86. Details on other applied instruments and their administration[5] can be found in Opachich and Kadijevich (1997), the subjects of which involved our 82 students.

As it was done for other subjects, themes suitable for matura work in mathematics were displayed at the school advertisement board in the beginning of spring semester. Bearing in mind Kadijevich (1998), under the label *Humanistic aspects of mathematics*, I listed 59 themes classified in five groups: *historical aspects of mathematics* (e.g. Early Greek mathematics), *epistemological aspects of mathematics* (e.g. Reasoning by analogy), *structural aspects of mathematics* (e.g. One formal system like modular arithmetic, finite geometry or geometry on sphere), *utilitarian aspects of mathematics* (e.g. Application of mathematics in music), and *didactical aspects of mathematics* (e.g. Multimedia approach to learning for theme of student's choice). Twelve students expressed interest in writing matura works in mathematics and they chose the following themes: Errors in the development of mathematical knowledge (two students), Application of definite integral, Solving problems in several ways, Application of mathematics in economy, Application of mathematics in psychology, Application of mathematics in sport, Isaac Newton, Early Greek mathematics, Application of mathematics in geodesy, Application of mathematics in history and Application of mathematics in astronomy. In the next tree months (March-May), I supervised them in their writings, applying a demanding approach. Aiming at fostering clarity and effectiveness, the students were required to produce short works in just few pages. Most works were revised three times.

Results

Means and standard deviations of the main measured variables[6] for the treatment groups were reported in Table 1. Significant differences between the groups were only found for mathematical self in grade 12 ($t = 2.10$; $df = 80$; $p = 0.04$).

Table 1: Means and standard deviations of the main measured variables for the treatment groups

Variable	**Group 1** (N = 72)	**Group 2** (N =10)
1. mathematical self in grade 9	.66 (.09)	.65 (.08)
2. mathematical knowledge in grade 9	.53 (.19)	.53 (.25)
3. mark in mathematics in grade 9	2.90 (.84)	3.20 (1.03)
4. mathematical knowledge in grade 10	.48 (.23)	.55 (.25)
5. mark in mathematics in grade 10	2.63 (.76)	3.00 (1.05)
6. mark in mathematics in grade 11	3.01 (.80)	3.00 (.94)
7. mathematical self in grade 12	.63 (.09)	.69 (.08)
8. mark in mathematics in grade 12	2.67 (.79)	2.70 (.95)

Means and standard deviations of the other measured variables for the treatment groups were reported in Table 2. Significant differences between the groups were not found.

Table 2: Means and standard deviations of the other measured variables for the treatment groups

Variable	**Group 1** (N = 72)	**Group 2** (N =10)
1. generalized self-efficacy in grade 9	21.4 (5.4)	22.3 (6.2)
2. intellectual self-efficacy in grade 9	41.1 (5.8)	38.8 (4.3)
3. external locus of control in grade 9	28.2 (6.2)	27.3 (5.6)

[5] Except for the tenth-grade test that was similar to the ninth-grade one and for the mathematical self and intellectual self-efficacy instruments utilized in grade 12 by the student writing matura work on application of mathematics in psychology who *gave the author of this study the named collected data when the school was finished.*

[6] While mark was expressed on scale 1-5 (the best), mathematical self and mathematical knowledge were rescaled to intervals (.02, 1) and (0, 1), respectively.

4. non-verbal IQ in grade 9	13.8 (3.9)	13.1 (4.3)
5. general school success in grade 9	3.96 (.53)	3.77 (.58)
6. general school success in grade 10	3.94 (.51)	3.76 (.61)
7. general school success in grade 11	3.93 (.67)	3.75 (.67)
8. intellectual self-efficacy in grade 12	43.2 (5.0)	43.0 (3.0)

Discussion

As a higher mathematical self was found for the subjects who wrote their matura works in mathematics, the study evidences that writing about mathematics in a humanistic context positively influences mathematical self. Such a finding is somehow in accord with Picker and Berry (2002) who found that meeting with a diverse panel of mathematicians could change negative images of mathematics and mathematicians.

The obtained finding may be opposed by saying »those who chose to write matura works in mathematics were simply those with higher mathematical self and thus the writing contributed nothing to the outcome«. However, as the values of several control variables measured in grades 9-12 evidence (see Tables 1 and 2), it is more likely that this finding was influenced by the treatment. Why may this be so? Since the author of this study taught mathematics in grades 9-12 to all subjects of the study, the only difference between the groups with respect to mathematics teaching/learning was the writing matura works in mathematics. And, the only differences concerning the measured variables between the groups were for mathematical self in grade 12 in favour of the treatment group.[7]

If one still continues to question such a conclusion, what explanation may he/she offer and what a counter argument may be put forward?

Since learning activities, especially inappropriate and/or demanding ones, usually decreases the initial level of the examined affective construct(s) (Sax, 1994 and Malmivuori, 2001; cf. Hill & Atwater, 1995) – it also happened in this study for the subjects outside the treatment (from .66 ± .09 to .63 ± .09; $t = 2.60$; $df = 71$; $p = 0.01$) – these ten students could have a high mathematical self before the treatment (above .69) that decreased during it, meaning that, for example, mathematical self in grade 11 or in the middle of grade 12 exhibited the same pattern as in the end of grade 12 with respect to the groups. As no difference between the groups were found for mathematical self in grade 9, such a change had to happen meanwhile, but could this really happen since these ten students can be regarded as a small representative sample of the whole generation of students. And again, although affective constructs are influenced by students personal features and/or their socio-cultural backgrounds (Malmivuori, 2001), no significant differences between the groups were found for the measured personal variables and the subjects' socio-cultural background were not varied. Knowing personally these and other students in the generation, it is very likely that this kind of questioning has a little weight.

Another problem with this study is the number of subjects in the treatment group. As already mentioned, just twelve out of 123 students wrote matura work in mathematics, which is about 10% of the whole generation. At that time, the number of students doing matura works in mathematics was about 10-15% in the generation in several Belgrade gymnasiums – most students were interested in other subjects and/or simply applied a tactical approach writing matura works in subjects whose demands were found easier (the easiest) – meaning that the treatment group was of a usual size.

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To summarize: despite some inadequacy of the applied method resulted from the pursued approach to this research[8], it seems that writing matura works on mathematical themes within a humanistic context positively influences mathematical self. Further research may thoughtfully study the impact of a humanistic approach to mathematics teaching/learning on affective variable(s) by applying more appropriate methods.

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[7] Significant differences between the groups were also found for mathematical self change (-.03 ± .09 vs. .05 ± .09; $t = 2.51$; $df = 80$; $p = 0.01$) again in favor of the treatment group.

[8] To avoid any students' suspect that their teacher was in fact carrying out (and would be carrying out) some research, all activities were spontaneously included in the teaching/learning process, especially the re-administration of the mathematical self and intellectual self-efficiency instruments done by a subject, future psychology student, writing matura work on application of mathematics in psychology.

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