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# Mathematical Resilience and Motivation to Study in Mathematically Gifted Students – Self-Determination Approach

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**Abstract**

**Aim.** This study aims to analyse the relationship between mathematical resilience (MR) and motivation (MOT) of mathematically gifted students (MG) through the lens of the self-determination theory (SDT). **Questions.** Based on a review of the results of previous research, the current study sought answers to four research questions revolving around the relationship between MR and MOT, the predictors of high mathematical achievement, the level and differentiations of dimensions of MR, and the types of MOT in a group of Polish MG high school students aged 16-18 (n = 113). The results of MG group were compared to a comparison group (n = 121). **Method.** The Mathematical Resilience Scale (MRS-24) and the Motivation to Learn Questionnaire (MLQ-30) were used to measure MR and MOT. Correlation analyses between indicators of the variables, regression analysis and statistical intergroup comparisons were conducted as well. **Results.** Significant correlations were found between MR and MOT in the MG group. The strongest predictors of high mathematical achievement in the MG appeared to be the students' beliefs regarding the value of mathematics, along with their overall level of MOT to learn. The level of MR was elevated in the MG and was observed to be significantly higher compared to that in the comparison group. The dimension analysis of MR indicated the particular importance of the perceived values of mathematics as the leading factor in this variable that most strongly differentiated the two groups. The analysis of MOT types in the MG depicted that they manifested mainly intrinsic MOT, identification and introjection, and the level of indicators of these three types of MOT distinguished in the SDT was significantly higher in this group than those in the comparison group. **Conclusion.** As indicated by the study, the promotion of the social value of mathematics is crucial in shaping students' MR and MOT as efficient problem-solving tools in school and daily life.

**Keywords:** mathematical resilience, motivation, mathematical aptitude, self-determination theory.

## Introduction

Following years of the primacy of analytical intelligence as the main characteristic of a gifted student, modern pedagogy focuses on the importance of emotional, motivational, and social competencies in the actualisation of intellectual potential (Lo & Porath, 2017). This was further clarified by Robert Sternberg's concept of successful intelligence, as well as the Munich Ability Theory (Heller & Perleth, 2008). Emotional and motivational resources are critical factors that support the development of abilities as well as their transformation into talents. The noticeable results of those resources in the educational process include the high school achievements of students (Gagné, 1995). High school achievements in mathematics have been widely recognised as a pedagogical criterion for determining mathematical aptitude (Sękowski, 2000; Knopik, 2019). Motivational determinants provide the energy base to sustain a long-term fascination with a subject or problem, as well as the determination to continue an academic activity despite setbacks (Heller & Perleth, 2008). Previous studies (Phillips & Lindsay, 2006; Clinkenbeard, 2012) have confirmed the role of motivation (MOT) in developing abilities in the achievement of personal goals, as well as sustaining progress despite difficulties.

Many studies have also revealed elevated levels of math anxiety in a significant number of high-achieving students (Beilock & Maloney, 2015). The explanatory hypothesis relates to the presence of increased MOT for high achievement in this group, as well as an aversion to experiencing failure (Ramirez et al., 2018). Higher levels of math anxiety in these students have also been linked to the value placed on math in their assumptions (Oszwa, 2020). In the modern world, mathematics is considered a significant field for the development of civilisation, along with individual and social values (Pieronkiewicz & Szczygieł, 2019). In the times of digital technology, mathematical aptitude is perceived as an imperative predictor of careers highly gratified in both financial and social aspects (Oszwa, 2017; 2020).

These factors may exert pressure on gifted students seeking high achievement. Therefore, it is crucial to assess and address this issue to shape their mental resilience (Lee & Johnston-Wilder, 2017) and support their MOT to learn. Such an attitude may have a positive effect on both the level of aptitude and the mental health of gifted students.

On the ground of educational practice, the main features of resilience include processes and mechanisms promoting well-being despite obstacles and hindrances (Masten, 2001; Luthar & Brown, 2007; Knopik & Oszwa, 2021). In the process of shaping resilience, three supporting resources have been highlighted: 1) individual protective factors, 2) family protective factors, and 3) environmental or social protective factors (Luthar & Brown, 2007). Resilience mechanisms have been analysed in the literature in the context of balancing adversity, reducing adversity, and gaining hardiness against adversity (Oszwa et al., 2017; Oszwa & Turska, 2017; 2018). In this study, the theory of self-determination (SDT; Ryan & Deci, 2000) has been chosen as the theoretical and analytical foundation. Based on this theory – the multidimensional correlation between mathematical resilience (MR) and MOT in mathematically gifted students (MG) has been determined.

## MR and the SDT

The specific model of resilience relating to mathematics developed by Sue Johnston-Wilder and Clare Lee (2010) is particularly relevant to the subject of mathematical aptitude. It implies an approach to learning mathematics by developing the ability to maintain positive emotions despite the difficulties and challenges that accompany mathematics education (Johnston-Wilder & Lee, 2017). The authors contextualised the model of MR on the theoretical background of a few separate well-known concepts in pedagogy and psychology (Seligman, 2002; Bandura, 2006; Yeager & Dweck, 2012; Ryan & Deci, 2020). The SDT is used in the structure of this model of MR in the conceptual layer (intrinsic MOT, perseverance) as well as in the mechanism of its formation (social support, meeting the needs of the student). Four evidences of the presence of SDT in the MR model can be identified.

First, the SDT attributes importance to shaping a student's intrinsic MOT, based on self-determination (Ryan & Deci, 2000). Personality constructs related to such types of MOT and MR include persistence and perseverance, with an emphasis on the latter (Johnston-Wilder & Lee, 2017). Perseverance implies persistent adjustment to the conditions of the task and not giving up despite facing difficulties.

> For a mathematically resilient learner, it is not sufficient to persist; perseverance is more important. Resilient students report much higher levels of perseverance, intrinsic and instrumental motivation to learn mathematics, mathematics self-efficacy, and mathematical self-concept and lower levels of mathematics anxiety than nonresilient students (Lee & Johnston-Wilder, 2017, p. 284).

Second, a strong pillar of MR is self-efficacy and self-control (Bandura, 2006), which is defined as the belief that success can be achieved as a result of self-determination and with an internal locus of control. A key source of self-efficacy in building MR is a teacher's perception of their student through the lens of the *growth zone model*, based on Vygotsky's idea of a zone of proximal development (Johnston-Wilder & Lee, 2010; Lee & Johnston-Wilder, 2017). The growth zone model consists of three psychological zones: 1) comfort, 2) growth, and 3) danger. In the comfort zone, a student feels safe while consolidating the mathematical skills being mastered. However, if the student stays in this zone for a long period, they do not acquire new skills and may feel bored due to a lack of new stimulation. In the growth zone, the student faces and overcomes challenges with a supportive teacher and then on by themselves. But if the tasks become too difficult and the effort is too intense, the student might want to return to the comfort zone. If this is not available, a prolonged state of tension can lead to feelings of danger and tension in relation to mathematics. At that point, the student is in the danger zone (Johnston-Wilder & Lee, 2010). Staying in this zone for a long period and experiencing unpleasant emotions can hinder the student's ability to solve math tasks and block further development in the mathematical field.

Third, the MR model refers to positive psychology and Martin Seligman's (2002) pedagogical optimism. An optimistic student views stumbling blocks as temporary and situation-related, rather than as resulting from permanent character traits that cannot be altered. This is strongly related to the development of their resilience and the maintenance of their general well-being (Lee & Johnston-Wilder, 2017).

Fourth, the MR model emphasises growth against students' fixed mindsets (Yeager & Dweck, 2012). Numerous studies indicate the educational value of teachers by highlighting the role of effort in the learning process, encouraging students to try over and over again despite failures, and seeing effort and commitment as the driving force behind their success (Yeager & Dweck, 2012; Pieronkiewicz & Szczygieł, 2019). Therefore, the growth mindset has been perceived by the authors of the MR model (Johnston-Wilder & Lee, 2010) as a crucial component of a student's MR, as well as an area of influence for a teacher. A teacher with a growth mindset is more likely to provide effective support to students in taking on mathematical challenges. With their growth mindset, these teachers may also play a key role in shaping students' MR and strengthening their MOT to learn mathematics based on internal engagement rather than belief in their innate mathematical gift.

In the MR model (Lee & Johnston-Wilder, 2017), three components of MR have been described: a) perceiving and appreciating the value and usefulness of mathematics in education and life (*value*), b) the belief that mathematics requires struggle and that problem-solving ability does not come immediately even for mathematically gifted individuals (*struggle*), and c) the awareness of the possibility of growth in mathematics through commitment and effort (*growth*).

## The Continuum of Motivational Regulation in SDT

Ryan and Deci (2020) listed six forms of regulation of an individual's relationship with the environment, which are distributed along a continuum of internalisation from amotivation through extrinsic MOT to intrinsic MOT.

*Amotivation* implies a total lack of MOT to act. *Extrinsic* MOT occurs when the reason for the undertaken behaviour is controlled by the environment, such as academic pressure from parents or teachers (Ryan & Deci, 2000; Góźdź, 2015*). Introjection* is a type of extrinsic MOT wherein the driving force behind an action is an individual's degree of commitment. It can be driven by the need to gain admiration or avoid guilt (Deci & Ryan, 2000; Ryan & Deci, 2020). *Identification* is related to the state where a student undertakes an activity because of the recognition that it will be valuable in the future. *Integration* is also a type of extrinsic MOT with the highest degree of internalisation and is the most similar to intrinsic MOT. A student with integrated MOT identifies with their school, is aware of the coherence of the stages of development and knows that the school teaches transferable skills towards self-realisation (Vallerand, 2001). The most desirable MOT in learning is *intrinsic motivation*, which refers to taking action because of curiosity, the desire to learn new skills, and the pleasure of studying, even if it is not related to immediate or distant external gain (Ryan & Deci, 2020).

On the foundation of the modern definition of giftedness, caring for the mental well-being of gifted students appears to be educationally important, and the results of comparisons of their MR and MOT with students having lower mathematical achievements may bring benefits in supporting all students towards increasing their mathematical achievements while maintaining their mental health.

## Method

**Research questions.** Based on a review of the literature, the current study sought answers to the following research questions:

Q1) Are there correlations between MR and MOT to learn in a group of MG?

Q2) What is the strongest predictor (in the dimensions of MR and types of MOT to learn) of high achievement in the MG group?

Due to the importance of mathematics in everyday life and a great number of students with learning difficulties in mathematics over the years, two more questions were formulated to compare MR and MOT in the MG group with those in the comparison group (i.e., the group without high mathematical achievements). The questions were as follows:

Q3) What are the level and differences in dimensions of MR (value, struggle, and growth) in the MG group of students as compared to those in the comparison group?

Q4) What are the level and differences in types of MOT in the SDT approach (intrinsic MOT, identification, introjection, extrinsic MOT, and amotivation) in the MG group compared to the comparison group?

**Subjects and procedure.** The study involved 234 Polish high school male (n = 90) and female students (n = 144), aged 16-18, from which a group of MG (n = 113) and a comparison group (n = 121) were formed. The main indicator for measuring the mathematical aptitude of the students was a pedagogical criterion in the form of their mathematics grades. The selection of individuals into groups was based on the average semester and the final grades in mathematics. Students with grades 5 and 6 formed the MG group, whereas students with grades 4 and below were included in the comparison group. The grading scale from 1 to 6 in the Polish education system is determined in the following manner: grades 1 and 2 form the lowest mark, grades 3 and 4 are average, and grades 5 and 6 are used for the highest mark.

The sample size was estimated using the G*Power application 3.1.9.7. For the introduced parameters (test power = 0.95, effect size $f^2 = 0.15$, number of predictors = 10), the obtained minimal sample size was 172.

The research was implemented in eight classes: three first classes and five second classes in four high schools located in two Polish cities, with 168 students living in the city and 66 students living in the countryside. All complete sets of results were used for analysis; however, eight of the original 242 sets were rejected due to missing data.

**Measures.** The Mathematical Resilience Scale (MRS-24; Kooken et al., 2015) was employed to measure MR. The scale consists of 24 items. The respondent's task was to mark on a seven-point Likert scale the extent to which s/he agreed with the statements, where 1 meant strongly disagree and 7 strongly agree. The results were analysed as an overall score (general level of MR), as well as in the form of three components: value, struggle, and growth. For validating the tool, Cronbach's alpha coefficients were 0.94 for the value dimension, 0.68 for the struggle dimension, and 0.80 for the growth dimension (Kooken et al., 2015).

MOT was measured using the Polish scale of Motivation to Learn Questionnaire (MLQ; Góźdź, 2015), which consisted of 30 items and was organised into five factors. It explained about 70% of the variance with high reliability measured by Cronbach's alpha internal consistency coefficients. The respondents considered each statement on a five-point Likert scale, with 1 being completely disagree and 5 being completely agree. The MLQ measured five dimensions of MOT discerned in the SDT (Ryan & Deci, 2020): a) amotivation (five items, Cronbach's alpha = 0.89); b) extrinsic MOT (four items, Cronbach's alpha = 0.75); c) introjection (seven items; Cronbach's alpha = 0.88); d) identification (seven items; Cronbach's alpha = 0.96); and e) intrinsic MOT (seven items, Cronbach's alpha = 0.93). Validation studies of the Polish version of the tool were conducted on a group of 1048 Polish students (Góźdź, 2015). The questionnaires were used according to the authors' guidelines; hence no adaptation activities were required.

## Directions and Methods of Statistical Analyses

To answer the research questions, correlations between the main and specific indicators of MR and MOT were measured and analysed. A stepwise regression analysis was also conducted. There was no conjecture on which predictor was the most strongly related to the explained variable. However, the conditions of the quantitative character of the variables and a linear relationship between the variables were met based on a scatter plot analysis and a normal distribution of rests.

Intergroup comparisons of the indicators were analysed using the nonparametric Mann-Whitney U test for the two independent groups. A non-parametric test was chosen due to the ordinal scale used in the questionnaires.

## Results

All indicators of the measured variables were analysed. For MR, the analysis included the MRS total score along with three scores for the value, struggle, and growth subscales. The indicators of MOT comprised the overall score and the SDT types of MOT: intrinsic MOT, identification, introjection, extrinsic MOT, and amotivation.

Correlations between MR and the measured types of MOT in the MG (Table 1) group appeared to be mixed, as shown in Table 1. The MRS total score correlated with the MLQ total score at a moderate positive level. A moderate positive correlation was also found between the value dimension in MRS and the overall score in MLQ. The correlation between the struggle dimension and the total score in MLQ was found positive and weak, while the correlation between the growth dimension in MRS and the total score in MLQ was statistically insignificant.

The correlations of MRS with intrinsic MOT also proved to be mixed: MRS value correlated highly with this type of MOT. Moreover, MRS growth showed a weak correlation, and the relationship between MRS struggle and intrinsic MOT was statistically insignificant.

The correlation between MRS value and MLQ identification, which is an external type of regulation very close to intrinsic MOT, was observed to be similar to those regarding intrinsic MOT. The correlation of MRS value with MLQ identification was positive and high, whereas the correlation between MRS growth and MLQ identification was weak, while MRS struggle and MLQ identification, was found to be statistically insignificant.

Introjection correlated with MRS indicators in either a weak (value dimension) or statistically insignificant (struggle, growth) manner.

Table 1. Correlations (Spearman's rho) between MR and MOT in a group of MG (n = 113)

| Indicators | Rho | MRS value | MRS struggle | MRS growth | MRS total score |
|---|---|---|---|---|---|
| **MLQ total score** | rho | .584** | .189* | .144 | .547** |
| | p | <001 | .045 | .129 | < .001 |

Table 1. (continued)

| Indicators | Rho | MRS value | MRS struggle | MRS growth | MRS total score |
|---|---|---|---|---|---|
| **Intrinsic MOT** | rho | .668** | .050 | .278** | .612** |
| | p | < .001 | .599 | .003 | < .001 |
| **Identification** | rho | .743** | .156 | .256** | .706** |
| | p | < .001 | .100 | .006 | < .001 |
| **Introjection** | rho | .359** | .107 | .097 | .347** |
| | p | < .001 | .260 | .308 | < .001 |
| **Extrinsic MOT** | rho | -.089 | -.011 | -.204* | -.182 |
| | p | .347 | .908 | .030 | .054 |
| **Amotivation** | rho | -.713** | .149 | -.306** | -.601** |
| | p | < .001 | .116 | < .001 | < .001 |

Source: Authors' research.

Negative correlations were observed between MLQ extrinsic MOT and MRS dimensions; however, they were either statistically insignificant (value, struggle) or weak (growth).

Amotivation correlated negatively with the MRS dimensions, ranging from high (value dimension) through weak (growth) to statistically insignificant (struggle).

In conclusion, the correlation analysis of MRS dimensions with MLQ motivations demonstrates a regularity in the MG in the strongest expression for the correlations between the value of mathematics as a dimension of MR and intrinsic MOT, identification (high positive correlations), and amotivation (high negative correlation). The other two dimensions of MR (struggle and growth) correlated either weakly or with no statistical significance.

Table 2A. Predictors of high achievement of MG. Regression analysis

| Model | R | R-square | Adjusted R-square | Standard error of estimation |
|---|---|---|---|---|
| 1 | 0.324[b] | 0.105 | 0.097 | 0.45934 |
| 2 | 0.380[c] | 0.145 | 0.129 | 0.45099 |
| b. Predictors: (Constant), MRSValue | | | | |
| c. Predictors: (Constant), MRSValue, MLQ overall score | | | | |

Source: Authors' research.

Table 2B. Predictors of high achievement of MG – ANOVA

| Model | Regression | The sum of squares | df | The average square | F | p |
|---|---|---|---|---|---|---|
| 1 | Regression | 2.74 | 1 | 2.74 | 12.98 | < .001 |
| | Rest | 23.42 | 111 | 0.21 | | |
| 2 | Regression | 3.79 | 2 | 1.90 | 9.31 | < .001 |
| | Rest | 22.37 | 110 | 0.20 | | |

Source: Authors' research.

Table 2C. Predictors of high achievement of MG

| Model | | Non-standardised coefficients | | Standardised coefficients | t | p |
|---|---|---|---|---|---|---|
| | | B | Standard error | Beta | | |
| 1 | (Constant) | 3.543 | .157 | | 22.604 | < .001 |
| | MRS value | .015 | .004 | .324 | 3.603 | < .001 |
| 2 | (Constant) | 3.918 | .226 | | 17.339 | < .001 |
| | MRS value | .023 | .005 | .496 | 4.261 | < .001 |
| | MLQ overall score | -.008 | .003 | -.264 | -2.269 | .025 |

Source: Authors' research.

The regression analysis illustrates that the general level of MLQ MOT and the MRS value dimension explained 12.9% of the level of mathematical achievement in the MG group (Tables 2A–C). Although this result is not high, it is statistically significant and allows considering these two factors (general MOT and value of mathematics) as potential predictors of high mathematical achievement of gifted students.

Table 3A. The level and dimensions of MR in the MG group (n = 113) compared with those in the comparison group (n = 121)

| Group | | MRS value | MRS struggle | MRS growth | MRS overall score |
|---|---|---|---|---|---|
| **MG** | M | 36.57 | 47.18 | 41.21 | 124.96 |
| | SD | 10.54 | 5.02 | 6.73 | 15.54 |
| **Comparison group** | M | 29.88 | 44.98 | 39.01 | 113.87 |
| | SD | 11.21 | 7.20 | 6.38 | 18.32 |

Source: Authors' research.

Table 3B. The level and dimensions of MR – mean and sum of ranks

| Indicators | Group | N | M rank | Sum of ranks |
|---|---|---|---|---|
| **MRS value** | 1 | 113 | 138.06 | 15601.00 |
| | 2 | 121 | 98.30 | 11894.00 |
| **MRS struggle** | 1 | 113 | 127.61 | 14419.50 |
| | 2 | 121 | 108.06 | 13075.50 |
| **MRS growth** | 1 | 113 | 129.06 | 14584.00 |
| | 2 | 121 | 106.70 | 12911.00 |
| **MRS overall score** | 1 | 113 | 140.53 | 15879.50 |
| | 2 | 121 | 96.00 | 11615.50 |

Source: Authors' research.

Table 3C. The level and dimensions of MR – Mann-Whitney U test

| Mann-Whitney U test | MRS value | MRS struggle | MRS growth | MRS overall score |
|---|---|---|---|---|
| U | 4513.000 | 5694.500 | 5530.000 | 4234.500 |
| Z | -4.493 | -2.210 | -2.529 | -5.029 |
| p | < .001 | .027 | .011 | < .001 |

Source: Authors' research.

In the MG group, MR achieved 124.96 points in the MRS total score, depicting 74% of the maximum score. However, in the comparison group, the overall MRS score was 113.87 points (68% of the max score; Table 3A). The levels of the three dimensions of MR varied in the MG group and were 66% for the value dimension, 84% for the struggle dimension, and 73% for the growth dimension. All levels of MRS indicators were higher in the MG group than in the comparison group, where the dimensions of MR reached 54% for the value dimension, 80% for the struggle dimension, and 70% for the growth dimension (Table 3A).

The MG and comparison groups differed significantly in the level of MR, in both the overall MRS score and the three dimensions of this variable (Tables 3B–C). The level of MR was observed to be significantly higher in the MG group. The greatest differences occurred in the value dimension, depicting the strongest impact on the variation in the MRS overall score between the groups.

Table 4A. Types of MLQ MOT to learn in the MG group (n = 113) compared to that in the comparison group (n = 121)

| Group | | Intrinsic MOT | Identification | Introjection | Extrinsic MOT | Amotivation |
|---|---|---|---|---|---|---|
| MG | M | 20.71 | 22.57 | 24.18 | 9.08 | 11.45 |
| | SD | 7.53 | 8.62 | 6.65 | 4.34 | 5.26 |
| Comparison group | M | 15.27 | 19.74 | 21.98 | 11.26 | 14.53 |
| | SD | 7.38 | 8.48 | 6.84 | 4.84 | 5.60 |

Source: Authors' research.

Table 4B. Types of MLQ MOT to learn – mean and sum of ranks

| Indicators | Group | N | M rank | Sum of ranks |
|---|---|---|---|---|
| **Intrinsic MOT** | 1 | 113 | 141.53 | 15993.00 |
| | 2 | 121 | 95.06 | 11502.00 |
| **Identification** | 1 | 113 | 129.08 | 14585.50 |
| | 2 | 121 | 106.69 | 12909.50 |
| **Introjection** | 1 | 113 | 129.15 | 14593.50 |
| | 2 | 121 | 106.62 | 12901.50 |
| **Extrinsic MOT** | 1 | 113 | 101.54 | 11474.00 |
| | 2 | 121 | 132.40 | 16021.00 |
| **Amotivation** | 1 | 113 | 97.48 | 11015.00 |
| | 2 | 121 | 136.20 | 16480.00 |

Source: Authors' research.

Table 4C. Types of MLQ MOT to learn – Mann-Whitney U test

| Mann-Whitney U test | Intrinsic MOT | Identification | Introjection | Extrinsic MOT | Amotivation |
|---|---|---|---|---|---|
| U | 4121.000 | 5528.500 | 5520.500 | 5033.000 | 4574.000 |
| Z | -5.255 | -2.532 | -2.546 | -3.498 | -4.382 |
| p | < .001 | .011 | .011 | < .001 | < .001 |

Source: Authors' research.

The differences between the MG and the comparison group in all types of measured MOT proved to be statistically significant (Tables 4A–C). The MG obtained higher values for indicators related to intrinsic MOT, while the comparison group achieved higher scores for extrinsic MOT and amotivation. For the intergroup comparison of types of MOT, intrinsic MOT appeared to be particularly important, along with identification and introjection, as the extrinsic regulations most closely related to intrinsic MOT.

In the MG group, intrinsic MOT was 60% of the maximum obtainable score, whereas, in the comparison group, it was only 43% of the maximum score. The level of identification was found to be 66% in the MG group and 57% in the comparison group. Introjection reached 69% in the MG group, but had only 63% presence in the comparison group. Extrinsic MOT was 45% in the MG group and 55% in the comparison group. Similarly, amotivation was significantly higher in the comparison group (58%) compared to that in the MG group (46%).

## Discussion

The SDT has been widely used in educational research aimed at measuring the effectiveness of the learning process by shaping students' intrinsic MOT (Niemiec & Ryan, 2009; Ryan & Deci, 2020; Guay, 2022). Besides motivational themes, the SDT has been used in studies focused on improving the quality of life of students and teachers (Deci et al, 1991; Deci & Ryan, 2000; Kuźma et al., 2020). In this context, it was deemed appropriate to assess the theoretical usability of the SDT in a group of mathematically gifted students.

The analysis of the results of the study revealed their consistency with the expectations based on the teachers' observations. In the MG, significant correlations were observed between MR and MOT to learn mathematics (Q1). Positive high and moderate correlations were revealed between MR and intrinsic MOT, as well as identification and introjection. This implies that an increase in intrinsic MOT causes an increase in MR, thereby causing an increase in intrinsic MOT in the MG group. Thus, intrinsic MOT can be perceived as a specific resilience resource in gifted students, a factor that stimulates the development of their potential (Knopik, 2019). This finding is imperative to designing support for this group of students. Hence, it should be focused upon in the motivational sphere, without being solely limited to cognitive stimulation (Lo & Pareth, 2007).

A detailed analysis of the MRS dimensions demonstrated the strongest positive correlation between the MG's perception of the value of mathematics and their MOT to learn. These results are in line with the assumptions of the SDT concept, according to which students' satisfied need for competence is a crucial factor to promote high school achievements (Ryan & Deci, 2020; Knopik & Oszwa, 2021).

In opposition to earlier research results (Kooken et al., 2015), the perception of difficulties in mathematics as an opportunity for growth and development in mathematical struggles did not depict a clear connection with MOT. The implication of this finding for educational practice relates to the efforts of teachers to demonstrate the value of mathematics in the process of education, as well as in everyday life, to shape and develop the MR of students. Similarly, the conducted regression analysis illustrated that the MG's beliefs regarding the value of mathematics, along with their overall level of MOT to learn, are significant predictors of high mathematical achievement (Q2). The level of MOT is significant to meet school requirements; however, simultaneously, the MOT is governed by the theories of students about the validity of the effort they put into learning. If mathematics taught at school acquires the status of a tool for thinking and problem-solving within the reach of students, the efficacy of learning and its social perception are likely to improve (Deci & Ryan, 2000; Bandura, 2006; Oszwa, 2020). Moreover, MG students have a particularly high need for competence and autonomy (Knopik, 2019), which implies that their engagement in learning is usually preceded by their analysis of the potential gains and losses from directing their attention to the exploration of a particular problem.

Analysis of intergroup comparisons in the study indicated the presence of significant differences in all indicators of MR and MOT. The level of MR, understood as self-determination and the ability to make further attempts despite difficulties, was found to be significantly higher in the MG than in the comparison group (Q3). Moreover, the overall level of MR of the MG was higher than average. The dimension analysis of MR indicated the particular importance of the MG's perception of the value of mathematics as the leading factor in MR, most strongly differentiating the two groups.

The analysis of MOT types in the MG group (Q4) depicted that the students mainly manifested intrinsic MOT, as well as identification and introjection. The level of indicators of these three types of MOT, as distinguished in the SDT, was significantly higher in this group than in the comparison group.

## Conclusions

The study results provide the basis for recommendations for the practice of teaching and learning mathematics by doing the following:

1) paying attention in the education system to the emotional and motivational factors, particularly while studying mathematics, since it may foster student achievement;
2) shaping MR through strengthening students' intrinsic MOT with identification and introjection; and
3) promoting the value of mathematics as a field of knowledge as well as an effective tool for solving everyday problems, as students' perceived value of mathematics enhances their MR to a greater extent compared to the struggle and growth dimensions of this variable.

## Limitations and further research

For future research, it would be advisable to include some of the limitations of the current study. For instance, in the selection procedure of MG, a psychological criterion of giftedness would be required along with the pedagogical criterion. The inclusion of environmental variables is also critical according to the assumptions of SDT. These variables could include the style and quality of teachers' work, teaching methods, attitudes of students, and attitudes of the teachers. Conduction of a mediation analysis can pose as an inspiring direction to establish meaningful relationships between the variables.

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