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PREDICTORS OF INSTRUMENTAL MOTIVATION FOR MATHEMATICS IN PISA 2012. THE ROLE OF GENDER, SELF-CONCEPT, HELPLESSNESS, NEGATIVE EMOTIONS, WORRIES AND INTRINSIC MOTIVATION

The aim of our study was to define predictors of instrumental motivation for mathematics. In our research, we used the data on the Polish sample of the Programme for International Student Assessment (PISA) from 2012. We hypothesized that motivation to engage in mathematics at later stages of education and in professional career, called "instrumental motivation" in the project, can be predicted based on gender, mathematics self-concept, intrinsic motivation, as well as worries about coping with mathematics and negative emotions. Using structural equation modelling, with gender and mathematics self-concept as predictors, and negative emotions, intrinsic motivation and worries about one's math skills as mediators, we showed that helplessness in mathematics, indirectly determined by gender and mathematics self-concept, has an indirect effect on instrumental motivation, only through higher worries about one's math abilities. Instrumental motivation turned out to be also strongly related to intrinsic motivation, which in turn is linked to a positive mathematics self-concept.

Keywords: learned helplessness, worries, negative emotions, gender, mathematics self-concept, intrinsic motivation, instrumental motivation

INTRODUCTION

Instrumental motivation, one of the forms of extrinsic motivation, can be defined as a willingness to engage in a particular activity which serves as a means for the achievement of other goals (Ryan & Deci, 2000; Vallerand, Pelletier, Blais, Briere, Senecal & Vallieres, 1992). In school setting, instrumental motivation is connected not only to different learning strategies (Wigfield, Eccles & Rodrigues, 1998; Yildrim, 2012), but also can predict students' study, course and career choices and even a desired profession. As shown by Ryan and Deci (2000), different sources of external and instrumental motivation may have effects similar to intrinsic motivation on the engagement in the learning process. A student whose main motivation is to be enrolled for particular studies or find a lucrative position in future, although motivated intrinsically, is highly engaged in the learning process which may result in a satisfaction similar to this of an intrinsically

motivated student. Hence, instrumental motivation can have a similarly strong effect on eagerness to learn as intrinsic motivation (Gardner & McIntyre, 1991).

Based on a theoretical analysis proposed by Ryan and Deci (2000), showing that motivation can be perceived as a continuum starting from extremely external, through a mixed type to a purely intrinsic one, it can be stated that although instrumental motivation can be connected to intrinsic one (Noels, Pelletier, Clement & Vallerand, 2000), it may not always be the case. The eagerness to follow a career in a particular domain that for example requires mathematics may stem not only from instrumental factors (Nauta & Epperson, 2003) but also from an interest and curiosity about the subject. However, a high level of instrumental motivation does not guarantee an interest in mathematics or pleasure of dealing with it, which are modified by intrinsic motivation.

Hence, apart from emotional factors related to the way classes on a particular subject are taught, the level of instrumental motivation can be predicted based on external motivation. Furthermore, research shows that negative emotions experienced on mathematics classes as well as worries about the ways of coping with the subject can effectively block both types of motivation (Ashcraft, 2002). Anxiety and helplessness on mathematics are likely to be more related to intrinsic motivation, which assumes taking pleasure from dealing with a subject, and less to instrumental motivation that can be generated by other non-emotional factors such as parental expectations (Ryan & Deci, 2000).

Finally, student's motivation to deal with mathematics at later stages of education can depend on the way the class is given and whether it is taught in an interesting manner. Studies on intellectual helplessness in the educational setting conducted in Polish schools (Krejtz, 2012; Krejtz & Bedyńska, 2009; Sędek, 1995) showed that if a teacher did not promote students' understanding of the material covered and instead concentrated on a rigid use of algorithms, students tended to have a higher level of math anxiety, helplessness, lower intrinsic motivation as well as lower achievement, measured both with school grades (Krejtz, 2012; Krejtz & Bedyńska, 2009; Sędek & McIntosh, 1998) and external assessments (Sędek, 1995; Sędek & McIntosh, 1998). Although it has not been empirically tested so far, it may be assumed that helplessness can have a negative effect on instrumental motivation and this relation is mediated by negative emotions and a decrease of intrinsic motivation. A student helpless in mathematics is unlikely to follow their career in a disliked domain, even if it could yield them numerous benefits such as a prestigious or a well-paid profession.

The authors of the cognitive concept of learned helplessness claimed that the effect can be a result of too much cognitive effort taken in unsuccessful attempts to solve difficult cognitive tasks (Kofta & Sędek, 1989; Sedek & Kofta, 1990). In school setting, such a situation may arise if a student tries to understand some matter, however the way the knowledge is delivered hinders them to do so (Sędek, 1995). It may be argued that intellectual learned helplessness can be determined also by factors other than the lack of teacher's competences to teach in a way that would promote understanding. Hence, both a teacher and a student have an influence on school performance, so the characteristics of the latter seem to be of significant importance. Such an assumption seems to be justified in light of studies showing that student's intelligence influences the level of learned helplessness (Konarzewski, 2006). Furthermore, research shows that the extent of learned helplessness can be moderated by gender; a common cultural belief suggesting that girls are not good at math additionally hinders math achievement (Baucom & Danker-Brown, 1979). Stereotype threat also turned out to be a significant predictor of intellectual helplessness on math classes but only by

girls with a positive self-image in this particular domain as well as a low identification with own gender (Bedyńska, 2013). Hence, in order to effectively predict the level of helplessness, one has to take into consideration student's self-concept in mathematics (Marsh & Shavelson, 1985; Marsh & Ellis, Craven, 2002). Furthermore, literature shows that self-concept has an effect on student's motivation, intrinsic and external alike (Vallerand, 1997; Vallerand et al., 1992).

Research aims and hypotheses

Using PISA 2012 dataset, we wanted to find predictors of instrumental motivation for learning mathematics as well as potential mediating variables. Our goal was also to expand on the consequences of learned helplessness, beyond school achievement and cognitive tests' performance examined in previous studies (Kofta & Sędek, 1989; Sedek & Kofta, 1990), by adding instrumental motivation as a dependent variable. Furthermore, we aimed at testing the mechanism suggested in previous correlational studies by Sedek (1995) in which intellectual helplessness may affect instrumental motivation through a decrease in intrinsic motivation as well as an increase in negative emotions and worries about mathematics. In order to achieve our research aims, we proposed a path model (Picture 1) and we tested it on a large sample of Polish students taking part in the Programme for International Student Assessment (PISA) 2012. We analysed direct and indirect effects between proposed predictors: gender and mathematics self-concept and dependent variable: instrumental motivation, with four mediators: learned helplessness, negative emotions, worries and intrinsic motivation.

HYPOTHESES

H1: Research on learned helplessness in the school context (Krejtz & Bedyńska, 2009; Sędek, 1995; Sędek & McIntosh, 1998; Krejtz, 2012) suggests that learnt intellectual helplessness evokes negative emotions and leads to a decrease in intrinsic motivation. We assume that helplessness measured in the PISA study will be associated with negative emotions and a decrease in intrinsic motivation. Taking into consideration the mechanisms of learned helplessness described in experimental studies (Mikulincer, Glaubman, Ben-Artzi & Grossman, 1991), we have grounds to believe that a high level of learned helplessness will lead to higher worries about one's performance in math classes. We hypothesize that worries, negative emotions and a lower level of intrinsic motivation for learning mathematics, resulting from the feeling of helplessness, will be related to instrumental motivation that predicts the willingness to engage in mathematics at later stages of educational and career development. We hypothesize that the aforementioned variables will mediate the relationship between helplessness and instrumental motivation.

H2: Based on previous research we have grounds to believe that gender and mathematics self-concept are two main predictors of variables included in the model. Research shows that girls tend to have lower intrinsic and instrumental motivation for learning mathematics (Nauta & Epperson, 2003) and a less positive mathematics self-concept (Hyde, Fennema, Ryan, Frost & Hopp, 1990). Girls have also more negative emotions and worries related to effective coping with mathematics (Hyde, Fennema, Ryan, Frost & Hopp, 1990; Ganley & Vasilyeva, 2015). Hence, we expect to see the same relationships in the PISA dataset. We hypothesize that helplessness, negative emotions, worries and intrinsic motivation can be also predicted based on mathematics self-concept which is a result not only of student's school experiences but also parental expectations and stereotypical beliefs about one's math performance (Abu-Hilal, Abdelfattah, Shumrani, Dodeen, Abduljabber & Marsh, 2014).

METHOD

Participants

The PISA programme tests students who a year prior to the assessment turned 15. One hundred eighty five schools were selected, from which 4 607 students took part in the study. Girls constituted 51.2% of the sample. Detailed information on the sampling procedure can be found in the Polish documentation for PISA (http://www.ibe.edu.pl/pl/o-instytucie/aktualnosci/293-pisa-2012-wyniki, p. 7)[1].

Instruments

The following variables were used in the study: intrinsic motivation, instrumental motivation, helplessness, mathematics self-concept, worries, negative emotions and gender (coded: 0 – males; 1 – females). All items forming particular factors were taken from the PISA 2012 Student Questionnaire – Form A and Form B, in which students marked on a 4-point Likert scale the extent to which they agreed that a statement described their attitudes and behavior. The answers ranged from 1 – "strongly agree" to 4 – "strongly disagree". For some answers, the scale had to be recoded. The Questionnaire, Technical Report describing the preparation and characteristics of the variables as well as the full documentation can be downloaded from http://pisa2012.acer.edu.au/downloads.php. All items loading particular factors are presented in the Appendix 1. Below, for illustrative purposes, we present only one item for each particular scale.

To measure instrumental motivation (INSTMOT) and mathematics self-concept (SCMAT) we used indicators prepared using Rasch model on multicategorical variables available in the PISA dataset. All estimators were estimated *a posteriori* (EAP). Instrumental motivation was measured with four items (e.g. "Learning mathematics is worthwhile for me because it will improve my career <prospects, chances>") and mathematics self-concept with five items (e.g. "In my mathematics class, I understand even the most difficult work"). A latent variable comprising of four items was calculated to measure intrinsic motivation (INTMAT). The items correlated highly with the new variable (ST29Q01 = 0.721; ST29Q03 = 0.775; ST29Q04 = 0.882; ST29Q06 = 0.844). Intrinsic motivation was measured with such statements as "I am interested in the things I learn in mathematics". One item was used to evaluate helplessness ("I feel helpless when doing a mathematics problem") which originally loaded the mathematics anxiety factor (ANXMAT). An indicator for negative emotions was averaged as it only comprised of two items. Worries about mathematics were measured using such statements as "I worry that I will get poor <grades> in mathematics", whereas negative emotions were diagnosed with e.g. "I get very nervous doing mathematics problems".

RESULTS

Statistical Analysis

The proposed model was tested using structural equation modeling (SEM) in MPlus software (Version 6.1., Muthén & Muthén, 2011). Both direct and indirect paths were analysed. In the first step, the initial model was tested. In the second stage of the analysis, all insignificant paths were removed and the second model was tested to verify whether it fit the data better (see Picture 1).

Due to the balanced repeated replicates with Fay's adjustment being used, only two fit indices – RMSEA (Root Mean Square Error of Approximation) and SRMR (Standardized Root Mean Square Residual) will be reported (Muthén & Muthén, 2011) as the standard chi-square statistics is not possible as a goodness-of-fit measure

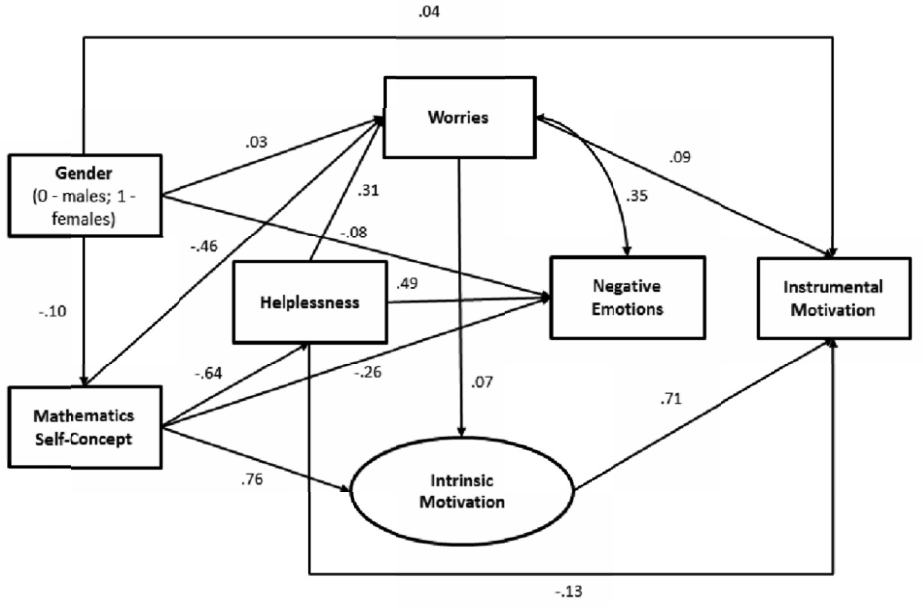
[1] http://www.ibe.edu.pl/pl/o-instytucie/aktualnosci/293-pisa-2012-wyniki, p. 7. Extensive information in English can be found in the PISA 2012 Technical Report available at *https://www.oecd.org/pisa/pisaproducts/PISA-2012-technical-report-final.pdf*

in the analysis of such replicate weights. We used the following criteria to test the goodness-of-fit: RMSEA < .05 for a very good fit and RMSEA < .10 for an acceptable fit as well as SRMR < .08 for a very good fit (McDonald & Ho, 2002). The Maximum Likelihood (ML) estimation method was adopted to estimate the fit of the model.

In the first step, we tested the initial model which considered all direct and indirect paths between the variables. The results showed that the model fit the data well (RMSEA = .05; SRMR = .03). The path estimates suggested that gender was related neither to helplessness (β = -.01; p = .91), nor to intrinsic motivation (β = .03; p = .14). The mathematics self-concept was not directly linked with instrumental motivation (β = -.06; p = .13) and helplessness was not connected to intrinsic motivation (β = -.05; p = .13). As intrinsic motivation (β = -.04; p = .27) and instrumental motivation (β = -.06; p = .13) were not related to negative emotions, the paths were removed from the model and the estimates for the simplified model were once again calculated.

The analysis of the simplified model suggested that the model fit the data very well (RMSEA = .05; p = .74; SRMR = .02). The comparison of BIC (Bayesian Information Criterion) and AIC (Akaike Information Criterion) of the two models showed that the simplified model fit the data better and explained 54% of the variance in instrumental motivation.

The Hypothesis 1 assumed that helplessness would be related to worries, negative emotions and intrinsic motivation which would mediate the relationship between helplessness and instrumental motivation. The path estimates showed that helplessness was related only to worries (β = .31; p = .001) and negative emotions (β = .49; p = .001). Instrumental motivation was related only to worries (β = .09; p = .001) and intrinsic motivation (β = .71; p = .001); however, the latter was a considerably better predictor than worries. Furthermore, helplessness in mathematics classes was weakly, albeit significantly, connected to instrumental motivation directly (β = -.13; p = .01) and indirectly through worries (for an indirect path, β = .04; p = .001) as well as wor-



Picture 1. The reduced model presenting only significant relations between variables. Latent variables are presented as an ellipsis and a square is used for observed variables. Left-right arrows mark covariance between variables.

ries and intrinsic motivation (for an indirect path, β = .07; p = .002).

The Hypothesis 2 assumed that gender and mathematics self-concept would predict other variables. The path estimates showed that gender (coded 0 for males and 1 for females) was negatively and not very strongly correlated with mathematics self-concept (β = -.10; p = .001) which goes in line with other findings suggesting that girls have a lower than boys math self-concept. Gender was also a weak predictor for instrumental motivation (β = .04; p = .03), worries (β = .03; p = .03) and negative emotions (β = -.08; p = .001). Such a result indicates that girls have a slightly higher instrumental motivation and the level of worries than boys but lower negative emotions. The correlations, however, are very weak and they should be treated with caution. Furthermore, the results showed that mathematics self-concept was strongly connected to worries (β = -.46; p = .001), helplessness (β = -.64; p = .001) and intrinsic motivation (β = .76; p = .001), as well as to a lesser extent with negative emotions (β = -.26; p = .001). Hence, it can be assumed that students with a more positive mathematics self-concept have higher intrinsic motivation and a lower level of worries, helplessness and negative emotions. The analysis of indirect paths showed that gender was correlated with helplessness through mathematics self-concept (for an indirect path, β = .07; p = .001).

DISCUSSION

The analysis of PISA 2012 data conducted on the sample of Polish students of lower-secondary schools showed that instrumental motivation can be predicted based on mathematics self-concept and intrinsic motivation as a significant mediator. This indirect path between the abovementioned variables was significantly stronger than the direct path between helplessness and instrumental motivation or the indirect path from helplessness through worries to instrumental motivation. Additionally, the results suggest that instrumental motivation is not related to negative emotions. However, a statistically significant and positive relationship between instrumental motivation and worries was observed.

Contrary to our assumptions, the analysis showed that helplessness on mathematics classes was not related to intrinsic motivation to learn the subject which contradicts the earlier results of Sędek (1995) who tested secondary school students. The lack of the correlation which was observed on a representative sample of Polish students of lower-secondary schools tested in PISA 2012 can be attributed to the following methodological issues: 1) in our study, helplessness was measured with a one-item scale and not twenty-one –item questionnaire used in Sędek (1995); 2) the measurement was restricted to helplessness and it did not include other symptoms of learned helplessness; 3) the sampled population of our study was younger; 4) we did not include potential moderators of the relationship as well as math achievement scores tested in Sędek (1995). The achievement is likely to be a key mediator of the path between helplessness and instrumental motivation. This assumption is a good starting point for further analysis of a new model.

Surprisingly, although in the PISA study helplessness on mathematics together with negative emotions load one factor (mathematics anxiety), the division of the items into three factors (helplessness, worries and negative emotions) leads to interesting results. Worries, similar to ruminations, have been identified as a variable mediating the relationship between helplessness and instrumental motivation. As such the variable can point to an important mechanism that can reduce negative consequences of learned helplessness on mathematics. Possibly methods reducing automatic negative thoughts, used in the cognitive-behavioural therapy (Ulusoy & Duy, 2013), could be an effective intervention in reducing helplessness. A further research in this area can have important practical implications.

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PREDYKTORY MOTYWACJI INSTRUMENTALNEJ NA MATEMATYCE W BADANIU PISA 2012. ROLA PŁCI, OBRAZU SIEBIE, BEZRADNOŚCI, EMOCJI NEGATYWNYCH I OBAW ORAZ MOTYWACJI WEWNĘTRZNEJ

ABSTRAKT

Celem artykułu było określenie predyktorów motywacji instrumentalnej na matematyce z wykorzystaniem danych polskiej części Programu Międzynarodowej Oceny Umiejętności Uczniów PISA 2012. Postawiono hipotezy, że motywacja do zajmowania się matematyką w toku dalszej kariery szkolnej i zawodowej, nazwana w projekcie motywacją instrumentalną, może być przewidywana na podstawie płci, obrazu siebie na matematyce, motywacji wewnętrznej oraz odczucia bezradności, obaw dotyczących radzenia sobie na lekcjach matematyki i negatywnych emocji. Analiza za pomocą modelowania strukturalnego, w której uwzględniono jako predyktory płeć i obraz siebie na matematyce, jako mediatory negatywne emocje, motywację wewnętrzną i obawy dotyczące własnych umiejętności matematycznych pokazały, że odczucie bezradności na matematyce, determinowane pośrednio przez płeć oraz obraz siebie, wpływa na motywację instrumentalną jedynie poprzez wyższy poziom obaw związanych z własnym radzeniem sobie na matematyce. Motywacja instrumentalna okazała się być także silnie powiązana z motywacją wewnętrzną, która z kolei jest uwarunkowana pozytywnym obrazem siebie ucznia dotyczącym matematyki.

Słowa kluczowe: wyuczona bezradność, obawy, negatywne emocje, płeć, obraz siebie w matematyce, motywacja wewnętrzna, motywacja instrumentalna

Appendix 1:

Intrinsic Motivation	1. I enjoy reading about mathematics.
	2. I am interested in the things I learn in mathematics.
	3. I look forward to my mathematics lessons.
	4. I do mathematics because I enjoy it.
Instrumental Motivation	1. Learning mathematics is worthwhile for me because it will improve my career <prospects, chances>.
	2. Making an effort in mathematics is worth it because it will help me in the work that I want to do later on.
	3. Mathematics is an important subject for me because I need it for what I want to study later on.
	4. I will learn many things in mathematics that will help me get a job.
Helplessness	1. I feel helpless when doing a mathematics problem.
Worries	1. I worry that I will get poor <grades> in mathematics.
	2. I often worry that it will be difficult for me in mathematics classes.
Negative Emotions	1. I get very tense when I have to do mathematics homework.
	2. I get very nervous doing mathematics problems.
Mathematics Self-Concept	1. I am just not good at mathematics.
	2. I get good <grades> in mathematics.
	3. I learn mathematics quickly.
	4. In my mathematics class, I understand even the most difficult work.
	5. I have always believed that mathematics is one of my best subjects.