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RESEARCH ARTICLE

INFLUENCE OF COGNITIVE ABILITIES, PERSONALITY CHARACTERISTICS AND SOCIAL STATUS ON PUPILS' SUCCESS IN MATHEMATICS

Vladimir Savic, *Dragan Popovic, Evagelia Boli, Milos Popovic and Jasna Popovic

Faculty of Sport and Physical Education, University of Pristina, Serbia

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ABSTRACT

Objectives: The study was conducted in order to apply adequate methodological procedures to determine the influence of cognitive abilities, personality characteristics and social status on success in the subject of mathematics.

Methods: For the purpose of determining the influence of cognitive abilities, personality characteristics and social status on success in mathematics with the pupils of the School of Chemical technology, we examined about 400 pupils in all four grades of the school. To evaluate the effectiveness of input processors or perceptual reasoning, IT-1 test was chosen. To evaluate the effectiveness of serial processor, or symbolic reasoning, AL-4 test was chosen. To evaluate the effectiveness of parallel processor, or identification of relations and correlates, S-1 test was chosen. To evaluate conative characteristics we chose CON6 measuring instrument by which we evaluated the following conative regulators: activity regulator, organic function regulator , defense reaction regulator, attack reaction regulator, system for coordination of regulative functions, as well as the system for integration of regulative functions. To evaluate social status a model constructed by Saksida was applied. Addendum INST2, questionnaire Boli & Popovic SSMIN was used. To evaluate pupils' success at school, we took school grades. All the data in this study were processed in the Multidisciplinary Research Center of the Faculty of Sport and Physical Education of Priština University by using software system for data processing DRSOFT. To determine the influence of cognitive abilities, personality characteristics and social status on success at mathematics, we used regression analysis. Algorithms and programs implemented within this work are shown in full, while the results of those programs were analyzed.

Results: Connection of the total system of predictor variables and success in mathematics amounts to: RO=.44, which explains mutual variability of 19%. The remaining 81% in the explanation of total variability of success at mathematics can be attributed to other abilities and characteristics of the subjects which were not included in this study.

Conclusions: From the above, it follows that those pupils of Technology school who achieve better success in mathematics have better symbolic reasoning, better educational and economic status, also have a higher grade in mathematics.

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INTRODUCTION

All the attempts to explain human behavior using only situational variables are unsuccessful, because the problem itself is set in a wrong way. The only reason for a particular behavior is not found either in personality variables or in situational variables taken separately, it is found in their interrelation, where an individual's activities and actions provide a new quality to the interaction. This problem can be brought under philosophical concept of science as is exceptionally and widely shown by Radonjić.

Corresponding author: Dragan Popovic,
Faculty of Sport and Physical Education, University of Pristina, Serbia

He says: "The nature has proved to be merciless towards scientists. While scientists aspire to simplicity and frugality in all theories, the nature scatters its abundance and diversity. Since nature will not adapt to the standards of science, scientists will have to adapt to the wealth and diversity of the nature". Menchiskaya points out that experiments and studies are often criticized for comprising only intellectual side of growth, not the personality of a pupil as a whole. She believes that the growth of the whole personality, not just an aspect of it, should be borne in mind. Starting from the above facts, if we really want to study behavior of an individual, primarily school success, we need to deal with their personality as a whole. Through psychological research in this direction, we

will try to explain which personality characteristics of a pupil lead to success and how they affect each other. So, on the basis of these and similar findings, general methodological framework of studying dependence of pupils' success at school has been extended from environmental variables to personality variables. Therefore, a higher and adequate level of the research approach should provide data on the level of development and a way of organization of those personality characteristics that are relevant for the pupils' success at school, that is, to determine contribution of each characteristic in the organizational structure of a personality during the educational process. Understanding of the contribution of certain personality characteristics and their organizational structures to educational effects enables us to establish schooling eligibility or to carry out certain educational interventions by measuring these characteristics. There is a large number of studies nowadays, but few, if any, scientific findings, on the dependence of educational success on differently organized characteristics in the personality structure. It cannot be claimed that the findings represent either scientific facts or principles and rules, they are more of logical and empirical indications on the level of probability and hypotheticality. Intellectual abilities, motivation, some wider personality dimensions, as well as social status of the pupils that will be discussed in the study are the exception. This study is characterized by complexity of the research problem the result of which will inevitably be close intertwining of the use of different methods and instruments for data collection and processing.

MATERIALS AND METHODS

The sample of subjects

In our case, the choice of sample of subjects was, among other things, conditioned by organizational and financial capacities necessary to conduct the research method. It was necessary to provide a sufficient of qualified and trained staff, certain instrumentarium, as well as standardized conditions in which to carry out the research. Limited funds and organizational possibilities influenced the fact that the measurement was not conducted in the whole of the Republic of Serbia, but only in a region. The measurement was carried out on random subjects representative for the whole population. To carry out the research properly, and obtain results stable enough in terms of sample error, it was necessary to pick a satisfactory number of subjects for the sample. The size of the sample for such a research is conditioned by the goals and tasks of the research, the size of the population and the degree of variability of the applied parameter system. Additionally, the number of subjects in the sample also depends on the level of statistical inference and the choice of mathematical and statistical model. Based on the chosen statistical-mathematical model and program, as well as goals and tasks, 221 subjects were included in the sample. During all factor procedures it should be constantly kept in mind that the analysis results depend on three main systems which determine the selection and transformation of information: sample of variables, sample of subjects and chosen extraction, or rotation method. With these criteria in mind, based on the experience from the previous studies, it is considered that the sample of 400 subjects is sufficient for this study. There were neither other restrictions nor stratification variables in defining population out of which the sample of subjects was taken. The population from which the sample of subjects was chosen consists of I, II, III and IV-grade pupils of the School of Chemical technology. The sample of pupils systematically covered four classes in each grade of technology school. When choosing, we took care that scientific and methodological demands are met, especially the size, representativeness and homogeneity which enable generalization of the study results to the entire population with high probability. The classes selected for the sample consist of the pupils who most likely have the same or similar social status characteristics like the classes that did not comprise the sample.

The use of this sample had the following objectives:

It is a fact that both in this country and abroad pupils' problems are insufficiently studied, which creates a certain gap in factual knowledge about the personality structure of pupils. The fact that four age groups were covered enabled systemic study of factors which may lead to certain differences in development of characteristics depending on the age or reflection of personality development of pupils of different age.

The sample of cognitive variables

These studies have provided unequivocal evidence that the structure of cognitive abilities is of a hierarchical type. General cognitive factor is on the top, whereas three primary factors of cognitive abilities are below. The three factors are related to: the effectiveness of perceptual processor (i.e. perceptual reasoning), the effectiveness of parallel processor (i.e. ability to identify relations and correlates), as well as the effectiveness of serial processor (i.e. symbolic reasoning). To evaluate the effectiveness of the input-processor, i.e. perceptual reasoning, IT-1 was chosen. To evaluate the effectiveness of serial processor, i.e. symbolical reasoning, AL-4 test was chosen. To evaluate the effectiveness of parallel processor, i.e. identification of relations and correlations, S-1 test was chosen.

The sample of conative variables

To evaluate conative characteristics CON6 measuring instrument was chosen by which we evaluated the following conative regulators:

Activity regulator (EPSILON),
Organic function regulator (HI),
Defense reaction regulator (ALFA),
Attack reaction regulator (SIGMA),
System for coordination of regulative functions (DELTA) and
System for the integration of regulative functions (ETA).

The sample of social status variables

To evaluate social status the model constructed from the part of the authors: Saksida; Boli, E *et al*. (2012, 2013, 2014) was applied. Addendum INST2 and questionnaire SSMIN were used in this research.

Dependent variable – pupils' success at school

To evaluate pupils' success at school, school grades were taken. Success was checked by means of knowledge tests which represent indicators of the acquired success and habits. In this research, pupils' success was presented by traditional grading system of this country, i.e. numerical grades from 1 to 5 at the end of a school year (so called final grade) Mathematical – logic sector: mathematics.

Results processing methods

The value of a research depends not only on the sample of subjects and sample of variables, that is, on the value of basic information, but also on the procedures applied for the transformation and condensation of those pieces of information. Certain scientific problems can be solved with the help of a large number of different, yet sometimes equally valuable methods. However, the same basic data and results obtained from different methods can lead to different deductions. This is the reason the problem of the choice of certain methods for data processing is quite complex. In order to reach satisfactory scientific solutions in this study, we firstly used correct, then adequate, unbiased and comparable procedures which corresponded to the nature of the stated problem and which enabled extraction and transformation of corresponding dimensions, the testing hypotheses on these dimensions, identifying differences, relations, prognosis and diagnosis, as well as establishing regularities within research field. Taking all of the above into account, for the research purposes, we chose the procedures which we believe correspond to the nature of the problem and do not restrict basic information too much. All the data in this study were processed in the Multidisciplinary Research Center of the Faculty of Sport and Physical Education of Priština University by using software system for data processing DRSOFT developed by Popović, D. (1980), (1993) and Momirović, K., as well as Popović, D. (2003).

Multivariate regression analysis in mahalanobis space

It is not clear who was the first to suggest performing a regression analysis of criterion variables in the space of continually distributed regressor variables after transforming the regressors into Mahalanobis form. That procedure was formally described in the work of Hadžigalić, Bogdanović, Tenjović and Wolf (1994), but fifteen years before that a program had been written in SS language, called ORTHOREG, Momirovic, D., Wolf, B., Popovic, D. (1999), which performs univariate or multivariate regression analysis in Mahalanobis space. A similar program of the same name was also implemented the SAS programming system, but it is limited only to the case where there is only one criterion variable whose position in the regressor space after all gives very scarce information. Since regression analysis in Mahalanobis space has some highly suitable comparative characteristics when compared to standard canonical model of multivariate regression analysis, in this work we will describe an algorithm which generates the greatest amounts of usable information on the parameters of the model. This algorithm was implemented by a program, written in Matrix language. Its performance is shown in some previous studies. Multivariate regression analysis of the criterion variables of Z_c in the space of Mahalanobis variables of M can be defined as a solution to the problem $Mb = Z_c + E \mid trag(E^tE) = minimum$. Since $M^tM = I$, is a solution that is easily obtained by differentiating the function trag (E^tE) is $b = M^tZ_c = R_{rr}^{-1/2}R_{rc}$ so the matrix of partial regression coefficients is in fact a matrix of ordinary product – moment coefficients of correlations between the regressors transformed into Mahalanobis form and criterion variables. Of course, the asymptotic variance of b_{jp} coefficient of the matrix b is therefore simply $s_{jp}^2 = (1 - b_{jp}^2)^2n^{-1}$, and the tests of hypotheses H_{0jp}: $b_{jp}^* = 0$ are simply $f_{jp} = b_{jp}^2((n - 2)(1 - b_{jp}^2)^{-1})$, because under H_{0jp}: $b_{jp}^* = 0$ variables f_{jp} have Fisher - Snedecor F distribution with 1 and n - 2 degrees of freedom. Regression functions are now defined by the operation $Y = Mb$ with a matrix of covariances $G = Y^tY = b^tb = R_{cr}R_{rr}^{-1}R_{rc}$, so the diagonal elements of the matrix $r^2 = (r_p^2) = diag\ G$ are normal determination coefficients; and since $Z_c^tY = R_{cr}R_{rr}^{-1}R_{rc} = G$, then r_p elements of r matrix are ordinary multiple correlation coefficients, so the tests of the hypotheses H_{0p}: $r_p^* = 0$ are defined by the functions $f_p = (r_p^2(1 - r_p^2)^{-1})((n - m - 1)m^{-1})$, because under H_{0p}: $r_p^* = 0$ functions f_p have Fisher - Snedecor F distribution with m and n - m - 1 degrees of freedom. Since the matrix of residual variables is $E = Z_c - Mb$, then $W = E^tE = R_{cc} – G$ is a matrix of their covariances. To identify regression functions, their correlations defined by the matrix $C = r^{-1}G\ r^{-1}$ could sometimes be of use, as well as the correlations of residual variables defined by the matrix $F = S^{-1}WS^{-1}$, where $S^2 = diag\ W$ is a matrix of variances of residual variables. The structure of regression factors in Mahalanobis space is simply $S = M^tMbr^{-1} = br^{-1}$, so sjp elements of the matrix S are ordinary product - moment correlation coefficients. Therefore, the asymptotic variance of sjp coefficients of S matrix $x_{jp}^2 = (1 - s_{jp}^2)^2n^{-1}$, and the tests of hypotheses H_{0jp}: $s_{jp}^* = 0$ are defined by the functions $f_{jp} = s_{jp}^2((n - 2)(1 - s_{jp}^2)^{-1})$, because under H_{0jp}: $s_{jp}^* = 0$ variables f_{jp} have Fisher - Snedecor F distribution with 1 and n - 2 degrees of freedom. Since b is, in fact, a correlation matrix, in the matrix $V^2 = b \bullet b = (v_{jp}^2)$, where $\bullet$ is Hadamard multiplication operator, there will be regressor variance components and criterion variables under this model of regression analysis. If we mark the sum vector of row g with e_g, and the sum vector of the row m with e_m, the elements of the vector $j^2 = V^2e_g$ will be fractions of the variance of each regressor which was involved in the prediction of a set of criterion variables; of course, in the vector $(e_m^tV^2)^t = vec\ r^2$ there will be coefficients of determination, so the elements in the columns of matrix V^2 are parts of the variance of each criterion variable which can be attributed to certain regressor variables. In tables and corresponding columns we calculated and demonstrated the following:

R – product-moment coefficients between each of the predictive variables and criteria.
PARC R – partial correlation coefficients of each predictor variable with criterion variable.
BETA – standardized regression coefficients, i.e. coordinates of the criterion vector projected into space of predictor variables.
P – percentage of contribution of each predictor variable to the explanation of criterion variable variance.

SIGMA B – standard deviation of the partial regression coefficients.
Q – likelihood of appearance of a beta coefficient, if the actual value of the coefficient is zero.

In the last part of the regression tables it is denoted by:

DELTA – determination coefficient, i.e. a part of the criterion variance, which can be explained by predictor variable variance.
RO – coefficient of multiple correlation among predictor variables.
SIG D – standard error of the prediction of the criterion variable on the basis of the system of predictor variables.
F – common F test for testing the importance of the multiple correlation coefficient with DF1 and DF2 degrees of freedom.
Q – likelihood of getting a certain value of F relation, if the actual value of multiple correlation is zero.

DISCUSSION

In studies on applied psychology, as well as other anthropological sciences, latent dimensions are generally estimated on the basis of the patterns of the variables formed within theoretical models which were the subject of verification in previous exploratory or confirmatory-oriented analysis of the latent structure of manifest anthropological variables. Hypothetical latent structure in applied research is thus explicitly defined, whereas hypothetical latent dimensions are covered by a large number of manifest variables whose measurement objects are known from the previous analyses or can be assumed with a high likelihood on the basis of theoretical, by rule cybernetically formulated models. In psychology literature, there are most often three types of the definition of intelligence. In behaviorist circles, intelligence is often identified with "learning capacity", that is, the ability to acquire new knowledge. It is less common to identify intelligence with "the ability of abstract thinking". The definition of intelligence as "the ability to adapt to new situations" is given special attention to. It is quite common in animal psychology. This, of course, does not imply to adaptation in terms of tolerance to exogenous factors, neither does it apply to adaptation in the clinical sense. Since success at school depends on a string of factors, it is very important to dispose of reliable indicators on which dimensions influence achieving maximum results and to which extent. Conative space represents a part of a personality in charge of modalities of human behavior. Since there are normal and pathological modalities, there analogically are normal and pathological conative factors. A characteristic of normal conative factors is that they are for the most part independent of each other and normally distributed in the population. There are few attempts to study normal modalities of behavior, as well as normal conative factors, so that subspace of a personality is not defined clearly enough. Pathological conative factors are much better defined in hitherto studies, and there are certain theoretical explanations for them in most of the cases. It is deemed that pathological conative factors are responsible for those types of behavior which reduce the adaptive level of humans considering their potential possibilities. The influence of conative factors is not the same on all the activities. There are activities that are less susceptible to the influence of conative factors, but there are also those to which the influence of these factors is crucial. The influence can either be positive or negative, depending on the factors and activities. So, there is no activity which would be completely independent of the influence of conative factors. The source of most problems related to the examination of social status, whether the status itself is the subject of study, or it serves as a control set of criteria in studying another phenomenon, lies in the nature of movement on the basis of which we determine the level of the subject position on a certain status criterion. In fact, most of the other anthropological characteristics can be exactly, reliably and objectively measured on the basis of general physical measures, or they can be estimated on strict enough metric variables, simply because they are the result of effective functioning of natural (physiological, biochemical and other biological) systems.

Basic importance as well as a basic way of functioning of these systems is, of course, regular and universal for each and every human being. There are undoubtedly individual differences, but they are the consequence of either genetically conditioned differences, or the effects of external stimulation (e.g. learning, or training), or they are the consequence of a disease or some other endogenously or exogenously induced disorders. However, the criteria for determining characteristics of social status are, as a rule, extra-individual and based on socio-economic structure of a society and collective value system, especially on the structure and effectiveness of how institutional mechanisms for regulating social relations function. That is why determination of the position of an individual in the social field is hard to be carried out by reasonable estimation, l*et al*one exact measurement. Status variables are by rule of actuarial type, the result of conventions which do not necessarily have to be guided by their real sociological importance, and the results are most often found on non-metric scales. Perhaps the biggest problem in studying social status, the problem of metric properties of status variables, arises from this. Simple coding operations which, at best, produce ordinal variables are performed over the information which is usually of an actuarial type; it is more often than not that because of the nature of the problem of the observed feature, a certain status variable also lies on a semi-ordinal scale. The best example is the variable often used to assess the social status of a family, related to the education of one or both parents. However, there are also other sources of methodological difficulties associated with the analysis of social status, and therefore with the construction of any verified theory of social differentiation, or social stratification, or class differences, or social distinction after all. Consideration of these theories and the way social status studies have been conducted so far show that the main methodological problems in this area are the following:

- Construction, or the choice of the model on the basis of which the universe of status variables is defined;
- Definition of the population to which the results of any study or formulation of any theory may relate, and the method of selecting a sample from the population;
- Determination of manifest status categories and construction of measuring instruments for their regulation

or measuring;
- Adequacy of the models, methods and techniques for data analysis and hypothesis testing.

Unlike many other anthropological phenomena for which several structural models (which differ from each other depending on their authors' scientific orientation) have been constructed during development of the appropriate sciences, at the moment there is only one single model of the social status structure, developed by a group of authors, associates of the Institute of Sociology and Philosophy, University of Ljubljana. This model, which had the most favorable reviews of sociologists from both eastern and western countries in its very first international presentation at the International Congress of Sociologists in Toronto in 1974, served as a basis for this study. In accordance with the goal of the study, regression analysis should show how cognitive abilities, personality characteristics and social status relate to the success in the subject of mathematics. Correlation between the whole system of predictor variables and success in mathematics is: RO=.44, which explains common variability of 19%. The remaining 81% in the explanation of total variability of the success in mathematics (Table 1) can be attributed to other abilities and characteristics of the subjects which were not comprised in this study. Detailed analysis of numerical values of regression coefficients and partial correlations clearly shows that correlation of cognitive abilities, personality characteristics and social status with success in mathematics primarily depends on the effectiveness of symbolic reasoning, as well as on the education of mother's father, pupil's general success, where the pupil and the mother spent their childhood, so on socialization subsystem. From the above, it follows that those pupils of Technology school who achieve better success in mathematics have better symbolic reasoning, better educational and economic status, also have a higher grade in mathematics.

Table 1. Regression of the grade in mathematics and predictor variables

	R	Partial R	Beta	t	Sig.
AL-4	.24	-.03	-.00	-.57	.00
IT-1	-.02	-.02	-.00	-.41	.67
S-1	.06	.05	.01	.92	.35
EPSILON	-.02	-,02	-.00	-.35	.72
HI	-.01	-.01	.00	-.16	.86
ALFA	.04	.03	.00	.58	.56
SIGMA	-.08	-.07	-.00	-1.24	.21
DELTA	-.11	-.10	-.00	-1.60	.11
ETA	.02	.02	.00	.33	.74
OBRAO	-.07	-.07	-.07	-1.13	.25
OBRAM	.19	.17	.15	2.78	.00
ZSJEZ	-.02	-.02	-.04	-.39	.69
ZSJEO	.08	.07	.11	1.15	.24
ZSJEM	-.09	-.08	-.16	-1.35	.17
TIPŠK	.00	.00	.00	.05	.95
KVALO	-.00	-.00	-.00	-.06	.95
KVALM	-.06	-.06	-.02	-.96	.33
ODEPO	.07	.06	.06	1.00	.31
ODPOM	-.15	-.14	-.14	-2.23	.02
ŠUSPE	.14	.12	.13	2.04	.04
IBSPO	-.02	-.02	-.02	-.38	.70
TMUPD	.20	.18	.32	2.94	.00
TMUPO	-,00	-,00	-,00	-.02	.98
TMUPM	-,15	-,13	-,23	-2.20	.02
Ro	DELTA	df1	df2	F	Sig
.44	.19	24	376	2.09	.00

Conclusion

This study was conducted with the goal to apply adequate methodological procedures for determining the influence of cognitive abilities and personality characteristics, as well as of social status, on the success in the subject of mathematics. For the purpose of determining the influence of cognitive abilities, personality traits and social factors on the success in mathematics, 400 pupils of the School of Chemical Technology from all the four grades of the school were selected. To evaluate the effectiveness of the input processor, or perceptual reasoning, IT-1 test was chosen. To evaluate the effectiveness of the serial processor, or symbolic reasoning, AL-4 test was chosen. To evaluate the effectiveness of the parallel processor, or identification of relations and correlates, S-1 test was chosen. To evaluate conative characteristics we chose CON6 measuring instrument by which we evaluated the following conative regulators: activity regulator (EPSILON), organic function regulator (HI), defense reaction regulator (ALFA), attack reaction regulator (SIGMA), system for coordination of regulative functions (DELTA), as well as the system for integration of regulative functions (ETA). To evaluate social status the model constructed from the part of the authors: Saksida Boli *et al*. (2012, 2013, 2014) was applied. In this study addendum INST2, questionnaire SSMIN was used. For the evaluation of pupils' success at school, school grades were taken. The success was checked by means of knowledge tests as indicators of the acquired knowledge and habits. In this study pupils' success is presented by traditional grading system of this country, i.e. numerical grades from 1 to 5 at the end of a school year (so called final grade) Mathematical – logic sector: mathematics. All the data in this study were processed in the Multidisciplinary Research Center of the Faculty of Sport and Physical Education of Priština University by using software system for data processing DRSOFT developed by Popović, D. (1980), (1993) and Momirović, K., as well as Popović, D. (2003). To determine the influence of cognitive abilities, personality characteristics and social status on success at mathematics, we used regression analysis. Algorithms and programs implemented within this work are shown in full, while the results of those programs were analyzed. Connection of the total system of predictor variables and success in mathematics amounts to: RO=.44, which explains mutual variability of 19%. The remaining 81% in the explanation of total variability of success at mathematics (Table 1) can be attributed to other abilities and characteristics of the subjects which were not included in this study. Detailed analysis of numerical values of regression coefficients and partial correlations distinctly shows that the connection of cognitive abilities, personality characteristics and social status to success in mathematics above all depends on:

- The effectiveness of symbolical reasoning;
- As well as on social status; mother's education, grandfather's (mother's father) education, general pupil's success and on where the pupil and the mother spend their childhood.

From the above, it necessarily follows that those pupils who have better symbolic reasoning, better educational and

economic status, as well as better general success, have better success in mathematics. They have better predisposition for learning mathematics, which is also justified from the aspect of the learning theory.

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