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Study of the Intelligence Structure of the Pedagogical Higher Education Institution's Students-Mathematicians as Their Professional Training Management Instrument: From Pedagogics of Opinions to the Pedagogics of facts

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ABSTRACT
The results of the study of the intelligence structure of the Pedagogical Higher Education Institution's students-mathematicians (Bachelors) of different years of study are provided. The study has been executed within the frames of Prof. G. Gardner's Multiple Intelligence Theory with application of contemporary digital technologies and statistics data computer processing. The experimental division of students by intelligence types has been complemented with the expert assessments. The obtained information related to the students' intelligence division by intelligence types gave a possibility to evaluate their cognitive preferences and represent the concrete ones, which aren't based on qualitative judgements, but on the quantitative data, recommendations (group and individual ones) on future teachers professional training process improvement.
Keywords: *Pedagogical Higher Education Institution, professional training of math teachers, Multiple Intelligence Theory, theory of generations, education management*

1. INTRODUCTION

In order to be high-performance and effective, the process of the future math teachers training at the Pedagogical Higher Education Institution shall consider their cognitive preferences both at the collective level (students group level) and at the individual level. It is necessary to remember, that, in fact, the contemporary students represent a generation "born with a smartphone in their hands" (they are also called a generation of "digital natives", a generation of centennials, Z generation). This circumstance as well as the Russian state's consistent focus on digitalization of all spheres of the Russian society life imply essential modification in the today's students' education process.

The theory of generations was suggested by Howe and Strauss in the year 1991 [1]; subsequently, these authors have been turning to this theory not once (see, for example, [2]). Many foreign and Russian authors have been turning to the analysis of social, psychological and other particularities of X, Y, Z generations; today this topic is still actual [3-17]. The works of the number of Russian authors [10, 12-15] are dedicated to the study of the centennials' psychological particularities and their training analysis. We shall mention some facts, necessary to be taken into account at interaction with Z generation representatives, and, especially, at their training.

The centennials (years of birth: 2000-2004 and on) interact with the world at the essentially different informational level, which hasn't been known before. For them, the Internet network, usually available through a mobile device, is an integrant part of life, containing communication, leisure, work, education. "The digital natives" don't mark the distinction between the life in online and outside it, assuming their identity, represented simultaneously in several spaces.

Nowadays, M. Prensky's *Digital Natives* concept [4, 8, 9] is considered to be prospective for comprehension of contemporary students' particularities. The digital natives are the digital language speakers and digital technologies carriers. The digital natives have indigenous knowledge of digital technologies, they take the digital world as the daily life, feel themselves in the multitasking stream, they are accustomed to the changes of information apprehension speed, gadget interactivity, to their own social network activity, to the video games world speed.

The new generations of students aren't similar to the previous generations – earlier, the studentship has never used such broad database as the Internet. The world network influence is noticeable in all human life aspects, and, naturally, the Higher Education Institution's education process can't ignore this fact. The education

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shall take the learner's cognitive activity psychological rules into account [14]. The studies show that now it is required to change means of education in order to adopt for values and styles of education of new learners, in particular, of Z generation representatives. The methods of education, courses, contents and objectives shall be relevant and attractive for the new generation of students, if the Higher Education Institution deems high quality education to be a priority for the learners.

Prensky [4] has opposed the digital immigrants – students and teachers of the elder ages, to the digital natives' generation, because all of them were born before broad use of the digital technologies, and that's why they aren't rather digital language speakers, but the immigrants in an alien country. The pedagogical and parent society has been divided in two camps: followers and opponents of the digital natives. A great number of this concept followers think, that contemporary students have essentially different abilities and possibilities, so the educational process shall be organized in another way. As it is stated in multiple blogs and mass media, some skills, which are significantly enforced by computer technologies (information parallel processing, ability to work with diagrams, technologies of random access to data bases), are extremely important for the education results, but aren't taken into account by the teachers [5].

It is of no importance, that the teachers pine over humanistic regression of their students, over lost skills of critical thinking and reflection, over ability to hold a dialogue, according to Palfrey and Gasser's opinion, they shall change themselves and teach in a new way. The higher education shall be built with accountance of students' opinion. The teachers' own motivation appeared to be destroyed due to feeling themselves as immigrants in the digital world, the mental panic effect occurred [6].

According to Ignatova's [13] opinion, a contemporary student:

- Wants to use his/her knowledge in a real-case scenario immediately.
- Works.
- Can find almost everything on the Internet.
- Builds his career consciously.
- Appreciates time and money.

The education world, as it is viewed by today's student, looks as follows:

- Old methods aren't interesting and *don't* work:
  - Reports.
  - Routine problems.
  - Easy tests.
- The following *is* applicable for effective education in the contemporary world:
  - Studies.
  - Collaborative works (cooperation culture).
  - Individual learning (autonomy).
  - Engagement with a problem (problem education).

Though, a number of studies didn't reveal precise expressed skills, which possess centennials of both genders in comparison with the predigital generation [3, 7]. There are no enough convincing evidences of the fact, that the contemporary students have specific multitasking skills or specific skills of information parallel processing. No essential data, proving, that the digital natives study in a fundamentally another way, has been revealed. An integral image of the digital generation hasn't still appeared. The spontaneous interaction with digital technologies isn't enough to form digital competence, required by the economical realities.

The real experience evidences, that the students need greater pedagogical support, than they acknowledge themselves [7, 11]. The earlier experience of acquaintance with digital technologies doesn't predesignate education results. We may see hazard in noncritical apprehension of digital information sources. If the students overestimate their abilities, they depreciate the importance of pedagogical accompaniment and organize the education activities incorrectly. At the same time the researchers note, that the digital ambient is a space, in which the old pedagogical models don't work [16].

It follows from everything abovementioned, that, first of all, for now, at discussing centennials education problems qualitative thinking and opinion prevail, but not reliably ascertained facts; in a greater degree it is common to the works of Russian researchers. Secondly, even though the surrounding digital environment exerts essential, to a great extent determinative, influence on today's students, they still need intelligent support of the teachers, but this support shall be relevant to the contemporary digital reality. As the long-time studies, executed by the author and colleagues, show, the math education of the contemporary students, future school math teachers of the Pedagogical Higher Education Institution, has its specific particularities [18-28]. For example, the necessity of the constant monitoring of the students math progress; necessity of constant motivation of the students, especially of those humanistically oriented, in studying math; importance of revealing mathematical foundations in the contemporary digital technologies and demonstration of math application in practical problems solution; teaching fundamentals of the education and research activities and project activities with the studied process or phenomenon mathematical model building to the future teachers, etc.

The objective of this work is the study of the intelligence structure (by Gardner, G.) of the Pedagogical Higher Education Institution's students-mathematicians (Bachelors) of different years of study and assessments, based on the obtained numerical data of the possibility of future school teachers professional training best possible management.

The hypothesis consists in the presumption, that the students intelligence structure study allows to evaluate their cognitive abilities and preferences quantitatively; on the grounds of the study data statistics analysis we can define the precise recommendation on optimization of the future math teachers professional training process at the individual and group (student group level) levels.

2. STUDY DETAILS

The study has been executed within the frames of prof. Govard Gardner's Multiple Intelligence Theory [17]. The methodology of the experiment and data statistics processing have been described above [29], so here we'll be limited to specifying main details.

"The Interrogation of the Students' Multiple Intelligence", containing 10 statements for each of nine intelligence types by Gardner, has been applied for the teachers' intelligence structure assessment. The interrogation has been developed by the Senior Lecturer of the Psychology Institute of the Ural State Pedagogical University, Vodiakha S.A. The essence of Gardner's intelligence types: 1 – linguistical; 2 – logical-mathematical; 3 – musical; 4 – interindividual; 5 – visually-dimensional; 6 – corporal-kinesthetic; 7 – intrapersonal; 8 – natural scientific; 9 – existential. The thinking of the interrogated ones has been expressed in the five-point numerical evaluation from 0 (the phenomenon is never evidenced) to 4 (very often) for each statement. Under the interrogation (testing) results, appears a possibility of quantitative assessment of the degree of interrogated persons different types of intelligence development.

The measurements have been executed with application of mobile devices in four academic student groups of the full-time Department of the Mathematics, Physics, Informatics and Technologies Institute of the Ural State Pedagogical University.

2 year of study. Group MI-1801 (17 people, ages from 18 to 20 years old), field of study 44.03.05 – Pedagogical Education. Specialization: Mathematics and Informatics. Group MI-1802 (15 people, ages from 18 to 19 years old), field of study 44.03.05.

3 year of study. Group MI-1701 (26 people, ages from 19 to 23 years old), field of study 44.03.05.

4 year of study. Group Mat-1601 (15 people, ages from 20 to 22 years old), field of study 44.03.01 – Pedagogical Education. Specialization: Mathematics; year of graduation: 2020.

3. RESULTS AND DISCUSSION

The results of measurements are provided on Figure 1 – Figure 8 in the form of histograms of division by the intelligence types by G. Gardner (Figures 1, 3, 5, 7), and in the form of frequency division in academic groups by the number of the scored points (Figures 2, 4, 6, 8).

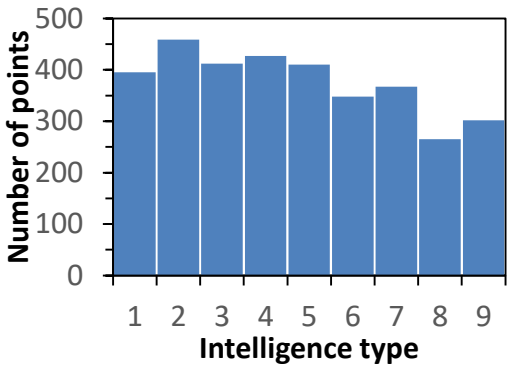

Figure 1 Distribution of number of points by intelligence types (by Gardner. G.); MI-1801 group

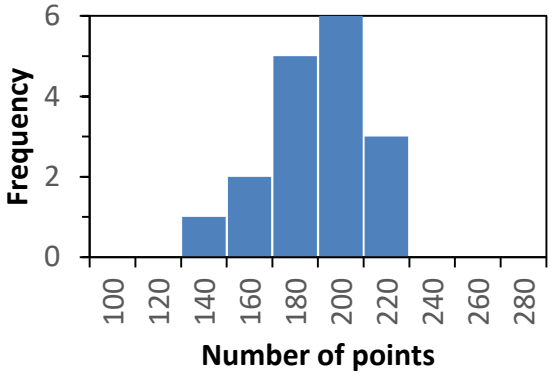

Figure 2 Frequency distribution of number of points by intelligence types; MI-1801 group

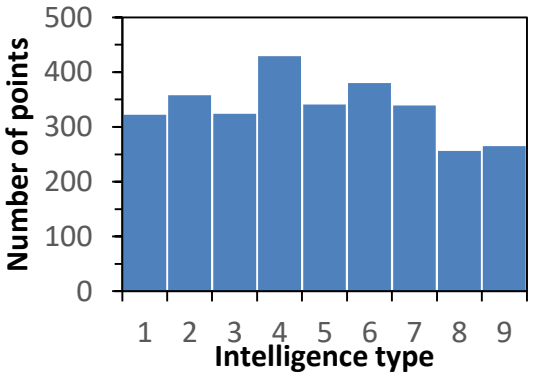

Figure 3 The same as Figure 1 for MI-1802 group

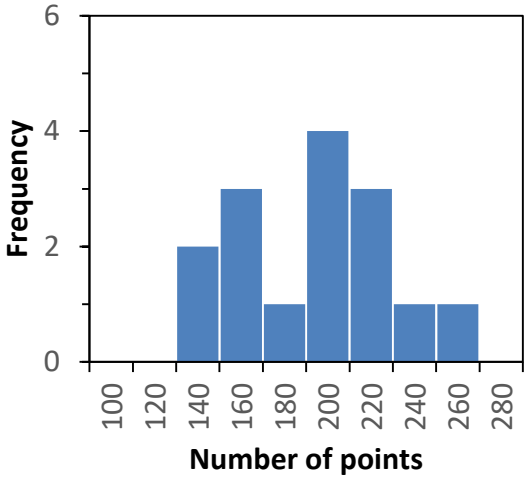

Figure 4 The same as Figure 2 for MI-1802 group

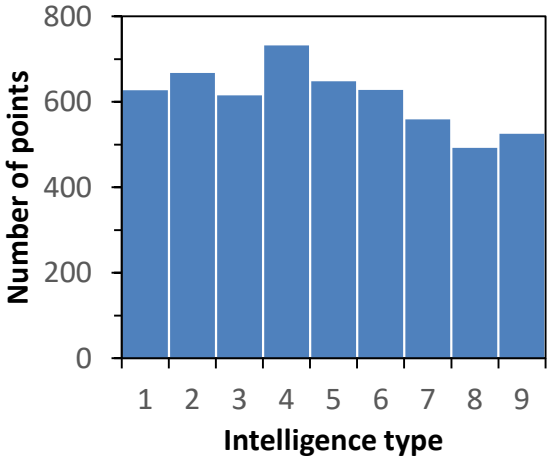

Figure 5 The same as Figure 1; MI-1701 group

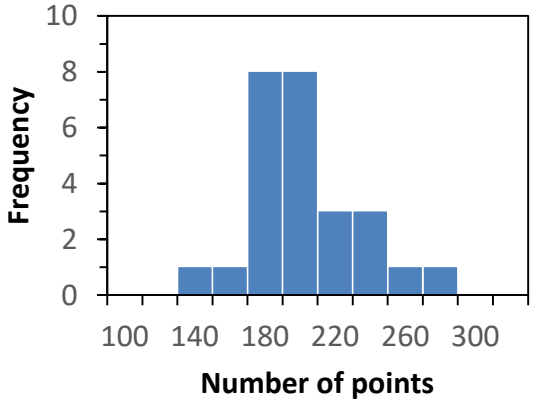

Figure 6 The same as Figure 2; MI-1701 group

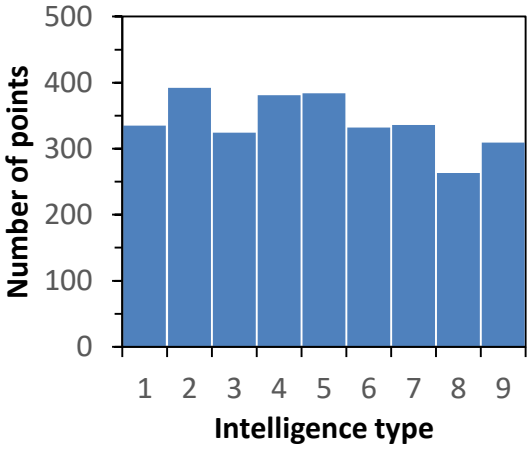

Figure 7 The same as Figure 1; Mat-1601 group

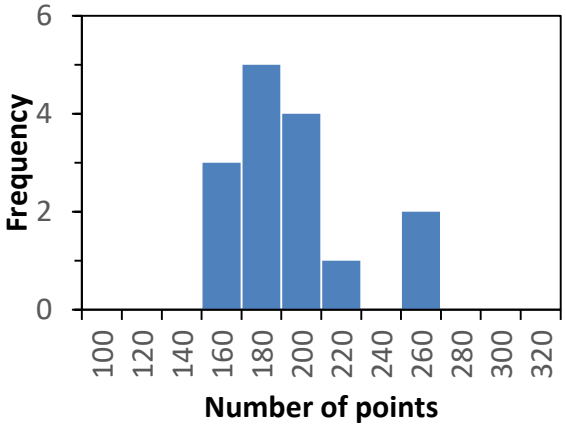

Figure 8 The same as Figure 2; Mat-1601 group

The analysis of histograms of division by intelligence types allows to make the following conclusion:

1) The priority (professional) development of the 2nd intelligence type (logical-mathematical intelligence), expected for a future math teacher, found distinct expression only for the group MI-1801 (2 year of study) and group Mat-1601.

2) Another professionally important intelligence type, the 5th one (visually-dimensional), found distinct expression (at the level of logical-mathematical intelligence) only for the graduation group Mat-1601.

3) The 4th intelligence type (interindividual intelligence) has been distinctly expressed for all of the students; along with the 2nd and the 5th intelligence types, the interindividual intelligence is professionally important.

4) The 3rd (musical) intelligence type is at a good level of development for all of the groups. Apparently, this fact may be deemed to be organically natural for the contemporary young people, who have free access to the best samples of the world music with the help of mobile devices. We should note, that as some researchers think, the progress in math is in enough close direct

correlation with the learners' musical education (see, for example, [30]).

5) The 8th (natural scientific) intelligence level is the less developed for all of the groups. In the context of the professional pedagogical activities, it means, that such math teacher is lightly capable to render assistance to the colleagues and pupils in application of math knowledges and solution of the natural science content problems (physics, astronomy, chemistry, biology, geography, etc.).

6) One more least developed intelligence type is the 9th one (existential). To a certain degree, it may be interpreted as the doubts of students in the social importance of a teacher's profession and in accuracy of their choice of the Higher Education Institution.

7) The frequency division of MI-1801 and MI-1701 groups is unimodal; herewith, the division for MI–1701 group is quiet indistinct; in the latter case the students' general intellectual development level differs by more than twice. A professor may expect problems at teaching professional cycle disciplines to such students, especially, when the students execute types of educational activity, implying independent creative activities (execution of course papers, creative tasks within the frames of specific disciplines, participation at students' scientific and research works, etc.).

8) MI-1802 and Mat-1601 groups frequency divisions are bimodal: in both groups two subgroups are distinguished. In MI-1802 group it is the subgroup with the low level of intelligence development. Alternatively, in Mat-1601 group the subgroup with the medium and high intelligence development level is distinguished. While teaching professional cycle disciplines to the students of these groups, the professor shall take into account the presence of intellectual stratification in these groups, for example, at preparing educational tasks of different levels for these students.

The standardized (the sum of all columns' heights amounts to 1) histogram of division by intelligence types (by G. Gardner) for Mat-1601 graduate academic group is provided on the Figure 9. The division is complemented with expert assessments of the desired division by intelligence types, provided by both students themselves and current professional math teachers (Gein A.G., Doctor of Physical-Mathematical Sciences, professor, Ural Federal University, and Nikulina G.N., I qualification category math teacher, Lyceum No. 88), who have almost semicentennial experience of pedagogical work.

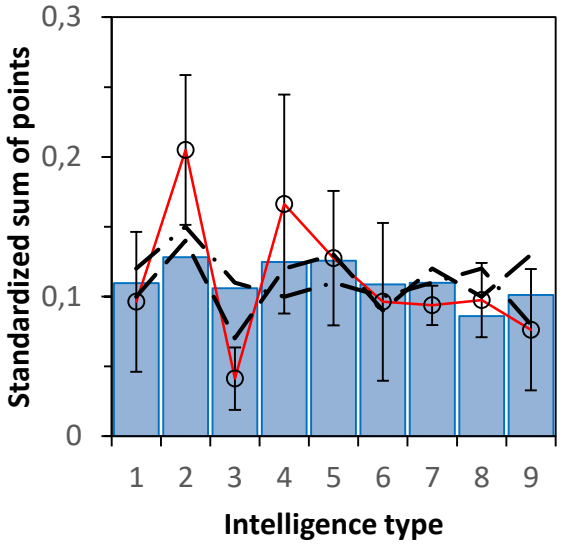

Figure 9 Standardized division of the sum of points by intelligence types; Mat-1601 group. Continuous line – expert assessment of the division for a professional math teacher, desired by the students (root-mean-square (standard) deviation in students' assessments is shown by the error bars). Dash lines show professional math teachers expert assessments: dotted line – Gein, A.G.; dot-and-dash line – Nikulina, G.N.

The analysis of data on the Figure 9 shows, that, in total, the expert evaluations of the graduates and experienced teachers are in qualitative agreement. Along with it, generally, the students would like to have a considerably higher level of logical-mathematical intelligence, than it is in fact. Likewise – in relation to the interindividual intelligence. According to the students' opinion, natural science intelligence also requires improvement. The respective assessments of the experienced teachers generally correspond to each other and they are more reserved, and, in average, they are also close to actually observed division. According to the opinion of the experienced teachers, the accent shall be on the logically-mathematical intelligence development. According to the opinion of the experienced experts, at teaching students, attention shall be also paid to development of the 8th intelligence type (natural science intelligence) of the future math teachers. Along with that, the large range of students' opinions (large standard deviation by almost all Gardner's intelligence types) evidences incompletely developed professional pedagogical self-determination of the graduates; obviously, the proper sufficient experience of practical pedagogical work at school is required for such self-determination.

The following recommendations on the math training process optimization come out from the executed analysis:

2 year of study, 3 year of study. The attention shall be paid to the improvement of the student's math professional training level (2nd and 5th intelligence types),

particularly, more problems with research elements, especially, geometrical problems, shall be solved. Specific attention shall be paid to the students' natural science intelligence development (8th intelligence type). We can achieve it, for example, at extensional solution of the problems with intersubject and practically oriented content, at execution of the course papers of correspondent subject-matter, at execution of math laboratory works.

4 year of study (graduate). During the time, remaining until the education completion, we shall concentrate at the graduates' natural science level development (see recommendations for 2, 3 years of study). The correspondent problematics may be additionally discussed in the students' graduation qualification works.

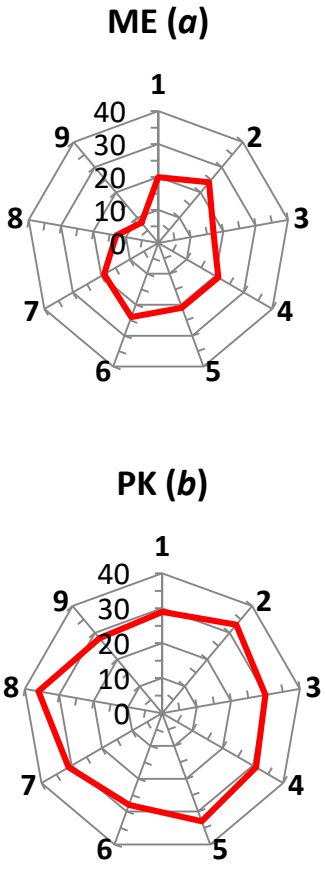

Figure 10 Individual division of the points by intelligence types: *а* – ME; *б* – PK; both – Mat-1601 group

For illustrative purposes, two individual divisions by intelligence types for Mat-1601 graduation group students (the surnames have been replaced with abbreviations) with the lowest (167) and the highest (167) sum of Gardner's points are provided on the Figure 10. The teaching in an academic group with such strong difference in the cumulative intelligence development of the students is quiet problematic: educational interests and possibilities of the students differ essentially.

It is clear, that ME student (Figure 10 *а*) needs to work intentionally at improvement of her intelligence development level by practically all intelligence types; probably, it is necessary to start with apprehension of correctness/incorrectness of her choice of pedagogical field of study. ME can be hardly recommended to work at a secondary school without additional professional retraining.

On the contrary, the Gardner's division for PK student (Figure 10 *б*) is close to uniform, which evidences quiet all-round development with expressed dominance of the 8th (natural science) intelligence type. If the student chooses practical work in the quality of a school math teacher after graduation, PK student may count on getting work at a high-level school, for example, the one with the improved level of studying physically-mathematical and natural science cycle disciplines. However, the most preferential option for PK student will be to continue education by the Master's degree, and then, by the post graduate program with the preparation and defense of a dissertation on completion of the Candidate of Pedagogical Science academic degree. The topic of the dissertation investigation may be, for example, connected to teaching pupils how to build and apply mathematical and digital computer/mobile models of surrounding reality.

4. CONCLUSION

So, the study of the intelligence structure of mathematicians-Bachelors of the Ural State Pedagogical University of different years of study, including the graduation year of study, was executed during the work within the frames of prof. G. Gardner's Multiple Intelligence Theory. The experimental division of students by intelligence types is complemented with expert assessments. The received information in division of the students' intelligence by intelligence types allowed to evaluate their cognitive preferences and develop precise ones, which aren't based on qualitative thinking, but on quantitative information, recommendations (group and

individual) on improvement of the future teachers professional training process improvement.
This study shall be treated as a working tool, implementing the authorial cognitive and activity approach to teaching mathematics [31] in regard to the digital evaluation of the students' cognitive possibilities and preferences. The activity component of the math teaching pedagogical process, as, though, any other educational disciplines at any educational level, shall be built in accountance with preliminarily achieved cognitive information.

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