The Technique to Evaluate Pupils' Intellectual and Personal Important Qualities for ICT Competences

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Abstract. The paper presents the ICT technique for assessment of schoolchildren abilities, intellectual and personal important qualities for ICT competences formation, as well as research in this domain. The results of comparative analysis of abilities of pupils with mathematical and IT abilities in non-profiled schools in relation to "average" abilities are presented after results of pilot study. Examples of methodical developments are given. Some expected and unexpected results of the experimental research are discussed.

Keywords: learning environment, intellect, personality, abilities, high school children.

1. Introduction

At present, our lives are being built more and more around digital networks. The cyberspace becomes the general environment of a human life and activity. F.e., Internet of Things (IoT) entered our life, about 13 different devices are on average in each house (computers, laptops and smartphones, routers, IP cameras, digital video recorders, etc.)**;** in 2018, more than 30 billion IoT-devices around the world were connected to the Internet.

New challenges of time and new directions of society development - Society 4.0, Education 4.0, penetration of the latest technologies into all spheres of life – need digital competences for everybody, not only specialists [1], because he/she becomes the element of the general intellectual capital [2]. As a result, the importance of information and communication technology (ICT) for education and training [3] requires the ability to process a large amount of information, to analyze the data obtained and provides it correctly using the appropriate and modern ICTs, including in synthetic environment [4], when the ability to work in on-line and off-line modes, as well as computer modeling is needed [5].

The **purpose** of the article is to analyze intellectual and personal important qualities needed for ICT competences of high school students in general (non-profiled) schools.

2. Related Work

Specialists in psychology and pedagogics articulate the necessity of forming a person at the beginning of the XXI century in both formal and informal education [6] with such professional skills as: informational literacy, inventive analytical thinking, quick search and processing of information, innovative thinking style, effective communication, project and team work, problem solving, ability to take responsibility, high productivity, and life competencies [7]. To date, special attention is paid to expand the digital competence by not only professional skills, but understanding threats from the digital environment [8], with special attention to information security culture [9] and recognition of new nature and features of todays' networks [10]. This corresponds the general requirements to IT skills [11], but it is needed to pay more attention to general cognitive abilities of a human [12] for most professions with regards to importance of the human intellect [13] and possibility to measure it in accurate manner [14], as well as a human personality features [15] that form a human as a specialist and as a workforce, and that should be formed effectively when using computer modeling in class work [16].

3. Method

In a screening study with the help of the ICT developed, and in order to identify the dominant fields of intellectual activity of high school students (grades 8-11), it was applied a methodology [17] and technique of psychological test performance, with subsequent analysis of data obtained. The *tests* included:

M. Luscher color and associative test (pairs comparison method); purpose of use is an assessment of stress, balance of psychological qualities; recorded parametersare as follows: total deviation (CO), Shiposh coefficient (VC), stress level (C), working capacity (RP), heteronomy-autonomy (GA), concentricity-eccentricity (KE), balance of personality traits (BL), the balance of the vegetative system (BV).

Myers-Briggs Type Indicator (MBTI); the purpose of use is an introspective questionnaire to indicate differing psychological preferences in how people perceive the world around them and make decisions an assessment of the ability to certain activities and individual properties of communication; traditional indices of an individual typology estimation according to the Myers-Briggs methodology are recorded based on the evaluation of the prevailing signs on the 4 criterion scales: extraversion E - introversion I (orientation of consciousness), intuition N - sensory S (way of orientation in a situation), thought/judgment J - perception P (method of preparation of decisions), thinking T - experience F (decision-making); in our research, we used quantitative evaluation of subjects' report on each scale, where each value was calculated as a sum of positive answers to the appropriate question.

Modified Intellectual Structure Test after R. Amthauer (TCI); purpose of the test use is a definition of the level of development and structural features of intelligence,

as well as attention, memory; the following subtests are used (the brackets show the corresponding structural component of the intelligence):

LS (testing of language, ability to formulate judgments),
GE (conceptual intuitive thinking),
AN (combinatorial abilities, mobility and ability to switch thinking),
RA (ability to solve practical computational problems character),
ZR (logical and mathematical thinking),
FS (figurative synthesis),
WU (spatial thinking),
ME (memory, attention).

The values of the structural components of intelligence were calculated as the sum of the correct answers for each subtest, the values of verbal (VI) and nonverbal (NI) intelligence were calculated as a sum of values, respectively, LS, GE, AN, ME and RA, ZR, FS, WU. The overall IQ score was calculated as the sum of values VI and NI multiplied by the correction factor 1.462 .

The resulting primary data was entered into a spreadsheet for further analysis. Test results were not personified, but were taken into account for each course separately.

The data analysis included:

- comparative evaluation of indices measured;
- visualization of these data;
- comparative analysis for three groups of pupils: with higher math abilities (g1), with higher IT abilities (g2) and general group (without abilities), according to teachers' marks (g3);
- stepwise discriminant analysis to reveal intellect and personality structure indices for comparable groups.

Subjects. In order to verify the effectiveness of the methodology, 43 pupils of 8^{th}, 9^{th} and 10^{th} grades of common school (non-profiled) were involved in the testing.

4. Results and Discussion

According to our prior results, intellect value of high school pupils of math and IT profile is significantly higher than in schools in average [18]. But schoolchildren participated in those research represented a selective sample, and their IQ was higher than 130, as a rule. Results of the intellect measurement in current research demonstrated that IQs in grade 9 was 102, 92, 76 (by groups g1, g2 and g3). Accordingly, IQs in grade 10 were 105, 101 and 80, i.e. a little bit higher, but significantly less than in pupils of profile schools. We strongly believe that it could be explained by "blurring" of classes because of children with different abilities.

Important characteristic of the intellect development is an intellect structure. According to the data known intellect framework impacts the creativity, very important feature of IT-competence. From the data obtained, such a structure of three groups analyzed in the research is relatively expected: higher for pupils of the g1 group and less values for g3 (Fig. 1).

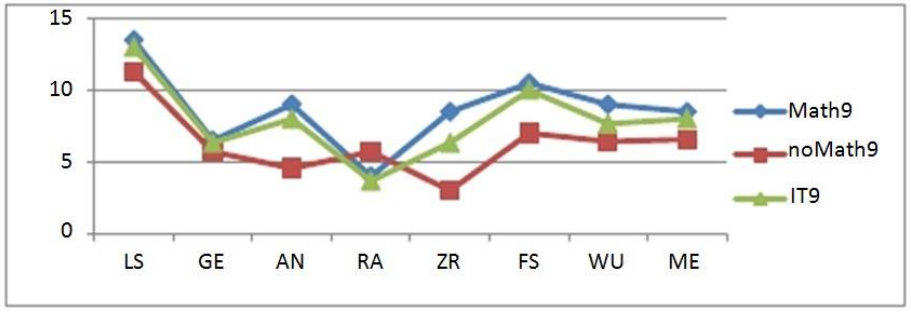

Fig. 1. Intellect structure of the 9th grade pupils.

However, unexpected result has been revealed in RA component: ability to solve practical computational problems character. Pupils of g1 and g2 groups coped with that task better.

At the same time, in 10th grade results of the test performance were as expected (Fig.2).

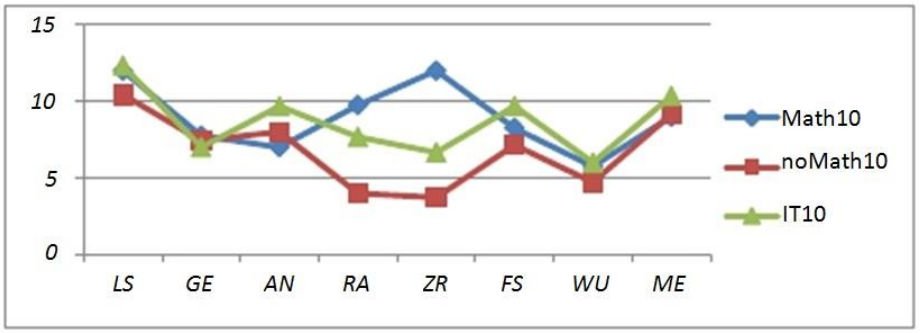

Fig. 2. Intellect structure of the 10th grade pupils.

It is necessary to highlight that personality structure of the pupils of the 9th grade was practically the same for pupils of g1 and g2 groups (Fig.3), significantly different from group g3, especially in decision-making on the base of emotions and introversion.

But 10th grade pupils' personality structure was similar for all three groups, though mindset (thinking T index) demonstrated "average" pupils (Fig.4). That result could be explained by their less formalized thinking and being ready for activity with "open mind".

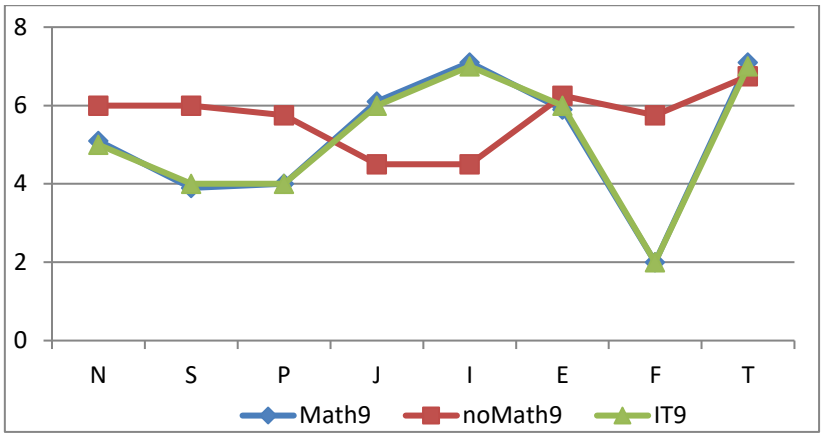

Fig. 3. Personality structure of the 9th grade pupils.

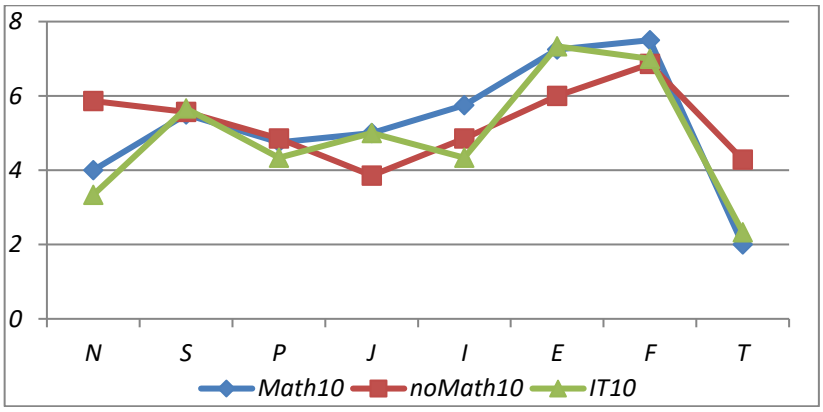

Fig. 4. Personality structure of the 10th grade pupils.

The next step of analysis has been carried out in relation to reveal what particular components of the intellect and personality could be used to differ groups under research, first of all g1 and g3, because they demonstrated not always expected tendencies. To solve that task it was used forward stepwise discriminant analysis to find which indices could describe those groups more reliable.

Significant indices from 27 intellect, personality and nerve balance features were included into the discriminant model step-by-step according to the criteria of the highest value of D^2-Makhalanobis factor (D^2-M). In this case, some additional values were calculated: group determination's coefficient of accuracy (DCA1 and DCA3, respectively), reliability coefficient for discriminant function (RDF). That technique was propose and developed by one of co-authors for data analysis in emergent industries [19].

The consequence of indices included into the discriminant model demonstrates that sensory S (way of orientation in a situation) and RA (ability to solve practical computational problems character) differs math-oriented pupils and others in the best way (Table 1). The next important indices (VC and BL) are associated with vegetative balancing of the human central nerve system and specify the group g3 practically with the reliability 100% (discriminant factor equal 1.0). But this is not enough to specify g1 pupils who are described good when the model includes intellectual thinking indices ZR and T.

Table 1. Building of the discriminant model for 10th grade pupils' g1 and g3

Step	Index	D^2-M	DCA1	DCA3	RDF
1	S (sensory)	5.87	0.5	1.0	0.8
2	RA (ability to solve practical computational problems)	11.95	0.75	0.83	0.8
3	VC (Shiposh' coefficient)	18.95	0.75	1.0	0.9
4	BL (balance of personality traits)	23.12	0.75	1.0	0.9
5	FS (figurative synthesis)	29.78	0.75	1.0	0.9
6	ZR (logical and mathematical thinking)	30.36	1.0	0.83	0.9
7	T (thinking)	30.40	1.0	0.83	0.9

The next steps after first 7 were not constructive, because accuracy and reliability of the groups' determination could not increase. In other words, pupils with mathematical and non-mathematical abilities in common classes can be separated by only 7 significant indices of: personality (sensory and thinking), intellect (ability to solve practical computational problems, figurative synthesis, logical and mathematical thinking), as well as personality balance (Shiposh' coefficient and balance of personality traits) with quite high accuracy and reliability.

This result demonstrated that schoolchildren of high school can have some clearly determined features even in common (non-profiled) schools that could be revealed, if using the appropriate ICT to reveal such "hidden" abilities, usually not determined in classroom.

At the same time, the results of such an analysis articulated that pupils with math and IT abilities have similar features in comparison with rest pupils, but all three set of test indices (intellect structure, psychological preferences and vegetative balance) are important in formation of psychophysiological portrait of studied g1, g2 and g3 groups. The question that is discussed in psychological literature up to now deals with the relationship of vegetative features and psychological preferences. In our field of interests, this relates to the specifics of IT-able pupils in high school. The analysis of such a relationship could not give a positive answer, i.e. such research should be continued, maybe on the biggest cohorts.

5 Concluding Remarks and Future Work

The technique proposed for assessment of "hidden" abilities of schoolchildren for the high non-profiled schools and realized as a special ICT can be used in common education practice. Indices (important to define math- and/or IT-abilities of pupils) include elements of the intellects structure, personality structure and balance of psychological qualities.

Problems that require further research in this area: extended research to collect more wide set of data from profiled and non-profiled schools with math and IT teaching.

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