Peculiarities of changes in the structure of intellectual and personal qualities of students of the ICT vocation

Oleksandr Burov, Svitlana Lytvynova and Yuliia Nosenko

Institute for Digitalisation of Education of the NAES of Ukraine, 9 M. Berlynskoho Str., Kyiv, 04060, Ukraine

Abstract

Almost all career guidance technologies, standards and approaches for IT-workers relate to technical or soft skills, but do not take into account that not all people can become the masters in IT domain because of some limitations of their abilities. Unfortunately, human psychological abilities are often out of HRs' focus. That is why, we wished to study important abilities of IT-learners in projection on professionally important qualities of IT professionals from point of view of evolution (changes) of some intelligence and personality indices on the edge of a human transition from adolescent to young adult as a future IT-specialist. It has been revealed that structure of intelligence can change at micro-age intervals over the high school and university learning, though the most popular view of researchers was relatively stable level of intelligence after 15 years-old. Besides, our research has demonstrated a difference in that structure in high school pupils and university students despite the fact that all students studied in specialized classes or faculties and represented selective samples. Our findings allowed to propose educators to adapt educational process of IT-learners with regard to specific and/or non-specific training such professionally important psychological qualities as ability to solve practical computational tasks and operation with spacial objects (both 2D and 3D).

Keywords

IT-learners, education, professionally important psychological qualities

1. Introduction

As noted in the materials of the World Economic Forum in Davos (January 2024), a teacher of specialized education can enter the top 10 professions on the labor market in the period 2023-2027 [1]. The EU's background materials note that vocational education has expanded and diversified over the past thirty years and now offers a huge range of subjects related to a wide range of occupations [2]. This is due to the fact that our lives are built more and more around digital networks. Cyberspace becomes the general environment of human life and activity. The new challenges of the time and new directions of society's development, such as Society 4.0, Education 4.0, and the penetration of the latest technologies into all kinds of life activities, require the digital competences of everyone, not just a specialist [3], because it becomes an element of the general intellectual capital. As a result, the importance of information and communication technologies for education and training requires the ability to process a large amount of information [4], analyze the received data and correctly provide it with the help of appropriate and modern technologies, including augmented reality [5] and artificial intelligence [6].

Modern professional and technical education allows people to get creative skills and personal development skills that can be transferred to others in the virtual space [7], as well as practical skills and activities specific to the chosen position [8]. Those who undertake vocational training or apprenticeships can expect to learn a lot about themselves and discover talents they did not know existed and optimize self-learning [9]. Moreover, vocational education is now available not only in school. There is now a wide range of full-time and part-time courses in higher education institutions and vocational colleges across Europe, as well as in-service training and apprenticeships, which are changing the motivation and capabilities of teachers [10], including in matters of maximum use students' potential, as well as

3L-Person 2024: IX International Workshop on Professional Retraining and Life-Long Learning using ICT: Person-oriented Approach, co-located with the 19th International Conference on ICT in Education, Research, and Industrial Applications (ICTERI 2024) September 23, 2024, Lviv, Ukraine

burov.alexander@gmail.com (O. Burov); s.h.lytvynova@gmail.com (S. Lytvynova); nosenko@iitlt.gov.ua (Y. Nosenko)

0000-0003-0733-1120 (O. Burov); 0000-0002-5450-6635 (S. Lytvynova); 0000-0002-9149-8208 (Y. Nosenko)

© 2024 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

CEUR Workshop Proceedings ceur-ws.org ISSN 1613-0073

CEUR-WS.org/Vol-3781/paper25.pdf

the safety of life and activities in learning environment including social networks [11].

Purpose. To analyze the variation of students' intellectual and personality qualities necessary for the formation of ICT competences during vocational high school and university learning.

2. Method

In a screening study with the help of ICT, it was developed. To identify the dominant fields of intellectual activity of high school pupils (grades 8-11) and university students (1-6 years), it was applied methodology [9], and technique of psychological test performance [12], validated previously in the professional selection of 850+ intellectual workers as well as in abilities' identification of 3500+ school children 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 parameters are as follows: summarized deviation (SD), Shiposh vegetative coefficient (VK), stress level (S), working capacity (R), heteronomy-autonomy (H), concentricity-eccentricity (C), balance of personality traits (BP), 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 an assessment of the development level and structural features of intelligence, as well as attention and memory [13]; 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 score II was calculated as the sum of values VI and NI.

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

The data analysis included:

- comparative evaluation of indices measured;
- visualization of these data;
- comparative analysis for grads (K8-K11) and university years (Y1-Y6);
- stepwise discriminant analysis to reveal intellect and personality structure indices for comparable groups.

Subjects. In order to verify the effectiveness of the methodology, pupils of 8th – 11th grades of high school (technological and nature-math classes, $N_p = 145$) and students of 1st to 6th year (the same vacation, $N_s = 257$) were involved in the observation process on-line (https://tests-beta.talents.center/) as highly motivated volunteers. Such a vacation was in the study focus, because these groups of vacations have similar intellect structure and and demonstrated similar dynamics in school grades [14]. The subjects in the study represented non-specified regions of Ukraine and who knew the reference to the site (via social networks or prompt communications) and had free access to the Internet in 2021-2023.

3. Intelligence as a dynamic structure

It is important for psychological and pedagogical analyses to take into account that children of the generation Z grew and got education when computers became widly accessed in comparison with previous generations. As a result, their intellectual and personal abilities seriously changed, firstly, in relation to less mental mathematical operations and requirements to memory, secondly, in relation to verbal and communication skills, especially needed for increased self-attractiveness. So, it is possible to expect that the structure and general level of the intelligence could change as well, and previously existed in 20th century view of psychologists on the intelligence's micro-age dynamics could become not so correct, in general. In addition, new professions, especially related to ICT, evoked new requirements for skills structure and their formation during education process at high school and university.

3.1. The evolution of the understanding of intelligence

At present, among the researchers of the problem of intelligence's study, there are two opposite trends in the interpretation of the nature of intelligence, which arose within the framework of the testological paradigm: one is associated with the recognition of a general factor of intelligence, the other – with the assertion of the existence of a set of independent intellectual abilities (intelligences).

Among the multitude of theories of intelligence, one group can be singled out: experimental psychological theories of intelligence. They became a kind of response to the unconstructiveness of testological theories of intelligence and were designed to identify the mechanisms of intellectual activity. Within the limits of the genetic approach, intelligence is understood as a consequence of complicated adaptation to the demands of the environment in the natural conditions of human interaction with the external world.

The recognized point of view has been formulated by J. Piaget, who believed that intelligence is the most advanced form of the organism's adaptation to the environment, which constitutes the unity of the processes of assimilation (reproduction of elements of the environment in the psyche of the subject in the form of cognitive mental schemes) and accommodation (change of these cognitive schemes) depending on the requirements of the objective world) [15]. He saw the essence of intelligence in the ability to make a flexible and stable adaptation to physical and social reality, and its main purpose is the structuring (organization) of human interaction with the environment. The internalization of object actions, i.e. their gradual transformation into mental operations (actions performed in an internal, imaginary plan), occurs depending on the accumulation and complication of the child's experience in practical interaction with objects. The development of intelligence is a spontaneous process of maturation of operational structures (schemes) that are gradually formed from the subject-life experience of the child.

We agree with this notion, but with regards to increasing role of the digital environment as a part of a human "natural" environment. Gen Zers are tech-depended. Especially, this is important for formation of professional activity of IT specialists, because IT vocational specialization is very popular at the basic school, and digital literacy is a core of the Reskilling Revolution launched by the World Economic Forum in January of 2020 (https://initiatives.weforum.org/reskilling-revolution/home). Besides, they are the first really digitally native generation, perhaps ready for earlier changes in the intelligence structure.

According to the theory of J. Piaget, 5 stages can be distinguished in this process (5 stages in the formation of operations) [15]. The 5th one relates promptly to our topic of research, because it is a stage of formal operations or reflective intelligence (11–12 to 14–15 years). At this age, formal (categorical-logical) schemes are formed, which allow building hypothetical-deductive reasoning on the basis of formal premises without the need for a connection with concrete reality. The consequence of the presence of such schemes is the ability to combinatorics (including the ability to combine judgments in order to check their truth or falsity), a research cognitive position, the ability to consciously check the course of both one's own and others' thoughts.

Thus, intellectual development is the development of operational structures of intelligence, in the process of which mental operations gradually acquire qualitatively new properties, such as coordination,

reversibility, automation, reduction. Such transformations of the intelligence can be considered as a basis for "The Theory of Multiple Intelligences" proposed by H. Gardner in 1983 [16] and in frameworks of other models (f.e., after R. Sternberg, Wu T. Wu). This approach to the intelligence analysis linked with the personality structure has been described in [12] and allows to propose:

- a *four-dimensional model of the structure of (successful) intelligence*, which is a generalization of the structural ideas of H. Gardner, R. Sternberg and Wu T. Wu, namely academic, personal, practical and creative vectors of intelligence;
- *three-dimensional psychological structure of the personality*, which involves the synthesis of all psychological properties of the personality in a three-dimensional, orthogonal space within three dimensions (coordinates): social-psychological-individual, activity and genetic (age, developmental).

This corresponds the idea that a human intelligence is evolutionary connected to the personality features and vise versa, a human personality is a result of his/her intellectual development. Thus, the social development of mankind naturally affects and needs the intelligence development with special attention to some components (sub-types) of it depending on the world economics transformation and appearance of new professions. Particularly, this is important if accounting the role of artificial intelligence in humans' life [6].

To date, hundreds of researchers still study the scientific domain "intelligence" and this is evolutionary process because of increasing role not only the general intelligence, but of its different structural components, from one hand, and new knowledge about them, from another hand. Besides, study of the intelligence nature is continuing from position of psychology, biology, pedagogics and technique. There are at least three interpretations of the concept of intelligence:

- *biological*: the ability to consciously adapt to a new situation;
- *pedagogical*: ability to learn;
- *structural/behavioral* (formulated by A. Binet): intelligence as "the ability to adapt the means to the goal."

In psychological literature, the concept of "intelligence" also has 3 meanings:

1) the *general ability* to learn and solve problems, which determines the success of any activity and is the basis of other abilities;
2) *system of all human cognitive abilities* (from feeling to thinking);
3) *the ability to solve problems* without external trial and error (in thought), the opposite of the ability to intuitively know.

Absence of generally-recognized definition of the term "intelligence" can indicate that study of this issue is still far from the finish, and any new knowledge and research results can help both the theory and practice. According to the goal and context of our research, we use the following philosophical definition proposed by the "Encyclopedia of Education" (Ukraine): Intelligence is "A holistic integrated mental formation that ensures the generation, construction and reconstruction of personal mental models of the world".

3.2. Intelligence changes at macro-intervals (Flynn effect)

Many researcher share the view that a human intelligence is formed in early years by 20 and left more or less stable after that. But the question is what the intelligence level can be from one generation to another if education, quality of life and technology development need its development? How can this corresponds to the so-called Flynn effect that means a rising intelligence test performance's results in the general population over time and generations? How can it varies across countries and intelligence domains, and its substantive meaning and causes remain elusive [17]? J. Pietsching and colleagues

carried out the first formal meta-analysis on the topic revealed worldwide IQ gains across more than one century (1909–2013) based on 271 independent samples, totaling almost 4 million participants, from 31 countries [18]. Key findings of their study included that IQ increased for about 3 points every decade in general, but varied according to domain and were stronger for adults than children, as well as have decreased in last decades. Later on, he revealed that there was evidence for a stagnation and even a reversal of the Flynn effect in a number of countries and showed that there was only little evidence for effects of migration, fertility, and mortality as substantive correlates of IQ decreases. In other words, "the stagnation of the Flynn effect may be explained by ceiling effects and diminishing returns of IQ-boosting factors, whilst its reversal can be attributed to negative associations with psychometric *g*" [19].

What is important in context of our study, according to authors, "Therefore, increases in specific abilities may have so far masked a *g*-based ability decrease. This idea is consistent with previously reported declines of reaction times (i.e., highly g-loaded measures) over the past century" [19]. From our viewpoint, decline of psychomentic tests can be especially acute for children of the gen Z, because their mental development and learning is happening in digital environment that does not require good short memory and quick mental operations that are favorite for a non-specific development of thinking abilities. So more particular study of the intelligence structure (more detailed intellectual abilities) can be useful for not only psychology, but for the pedagogy and namely learning of ICT students.

3.3. Intelligence changes at micro-age intervals

There are known not so many studies of the intelligence development over high school and university period, both by screening and monitoring methods. Such research, especially experimental ones, have a number of difficulties. F.e., a change in the composition of students in a school class, especially when moving from basic to high school; changing the pupil's learning vocation; changing the composition of students' group; improvement of education techniques and methods, especially because of implementing innovative digital technologies etc.

E. Budrina's dissertation study demonstrated that the dynamics of intellectual development in adolescence (taking into account the peculiarities of the manifestations of convergent, divergent and stylistic properties of the intellect) has a non-linear, multidirectional character. At the same time four possible types of changes in the indicators of the intellect properties were empirically recorded: progressive, stagnant, regressive and jumpy. Leap-like changes are mainly associated with a drop in the productivity of intellectual indicators at the age of 13-14 years, as it was known from other publications [20]. At the same time, the nature of changes can be affected by the interaction of age, education model, specialization of education, and sometimes gender and can influence on the individual learning style.

Tens of thousands of intelligence changes' studies have been conducted worldwide. However, data on micro-age changes in the relationship between psychometric intelligence and its dynamics are insufficiently presented in scientific publications and have varying outcomes.

Studies of the age dynamics of intelligence have identified a number of microperiods in the development of intellectual abilities of individual intelligence components [21]. Unlike an adult, school ontogeny is characterized by a greater amplitude and frequency of microwave oscillations. The author highlighted that the "classical verbal" factor begins to stand out since 9^{th} grad (15 year-old) and it is the most significant in the next year, but some non-verbal indices started to increase [21]. In the last school year, the structure of non-verbal intellect began to transform more active. That study has confirmed that the sensitive period for the formation of the intellectual system can be considered the age of 12-13 years (8^{th} grade). In addition, those results pointed to clear differentiation of indices of verbal and non-verbal intellects by screening method in senior schoolchildren of the comprehensive school, without vocational differentiation, in 2002.

According to the experimental data obtained under the leadership of B. Ananiev, the process of psychophysiological development of adults is heterogeneous and contradictory. From 18 to 25 years, the main age period of the university students, the level of development of thinking is higher than the level of development of attention. Increases in the level of development of attention occur at the age

of 22 and 24, when there is a decline in the level of development of thinking. At low indicators of the development of attention, their relative stability is preserved, and variability is noted in thinking at high indicators. In the future, the dynamics in the ratio of levels of development of thinking and attention changes [22]. These findings are important for designing etaching process of students, because they correspond to the age 17-22 years-old group and obtaining of the particular professionally important skills could be optimized in this way.

Vocational influence to the intelligence structure has been studied by V. Bodriakov and N. Fomina [23]. The results are discussed of longitudinal psychology – pedagogical studies of the structure of the intellect of students – the mathematicians of the pedagogical university. Measurements are carried out in period 2000 – 2012 with the aid of the Test of Amthauer. It has been revealed that indicators of the intelligence structure of first-year students in different years of admission were different, though mathematician students can be considered as a "selected" sample because of strong specific of requirements for them. Besides, indices of 6 from 9 intelligence subtests by students of all years were lower than appropriate indices of professional mathematicians. It was recommended to pay special attention and training of such qualities during the education period.

It is possible to conclude that intelligence is a dynamic, developing system, and "slices" of the state of the intellectual system can be adequately understood only in the context of the principle of development and targeted function. According to the author of the structural-dynamic theory of intelligence D. Ushakov, the structure of intelligence is a result of individual intellectual development and takes place by interaction of three main factors such as individual intellectual potential, cognitive mechanisms of intellectual functions and the influence of the environment. But we strongly believe it is reasonable to add one more important factor "purposeful mental activity" that can play a significant role in adolescence, because such an activity affect the structure of intelligence transformation.

4. Results and discussion

As it has been demonstrated in our past pilot study, 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. Those results of such an analysis articulated that pupils with math and IT abilities (8th-10th grads of the same school) had similar features in comparison with rest pupils, but all three set of test indices (intellect structure, psychological preferences and vegetative balance) were important in formation of psychophysiological portrait of studied groups. The question that was discussed in psychological literature up to now dealt with the relationship of vegetative features and psychological preferences.

Because have found that math and IT abilities had similar features, we analyze these two vocational groups together in this study, paying particular attention to dynamic changes of indices registered over a time of school and university. The method of analysis was a screening observation that can produce another results than monitoring of the same young people during the same period. But, at the same time, the monitoring has its own 'incorrectness' because of "jumping' of environment and social conditions when former pupils cross the boundary of school learning. Besides, according to practice, many math school pupils change their vocational education and prefer to obtain IT professions, as well as some of IT pupils can go to another professions. From this point of view, both university future professions (students of IT and math) are not represented by only school pupils of the same vocation.

Understanding these difficulties in maintaining uniformity in school and university learning groups in the specified professions, as well as keeping in mind the final goal of university education (to become a professional in IT), we study indices of intelligence (Int), personality (Pers) and balance of psychological qualities (BPQ) of subjects performed corresponding tests on-line as volunteers who were motivated to get real information concerned their special features important for IT specialty. The starting point to use particular these tests was findings of B. Shneiderman who clearly demonstrated efficiency of such an approach for understanding psychology of software designers [24].

Data obtained after investigation (tests performance) were averaged by the year of learning (4 high school years, 4 Bachelor's degree, 2 Master's degree; SY, BD and MD, respectively) indices included in analysis: 11 indices of the intellect structure, 8 indices of personality and 8 indices of BPQ.

From the first look, results of verbal (VI), non-verbal (NI) and integrated (II) intelligence indices' change over 10 years can be unexpected (figure 1), because they increase year-by-year at school, are lower in BD, and increasing in MD.

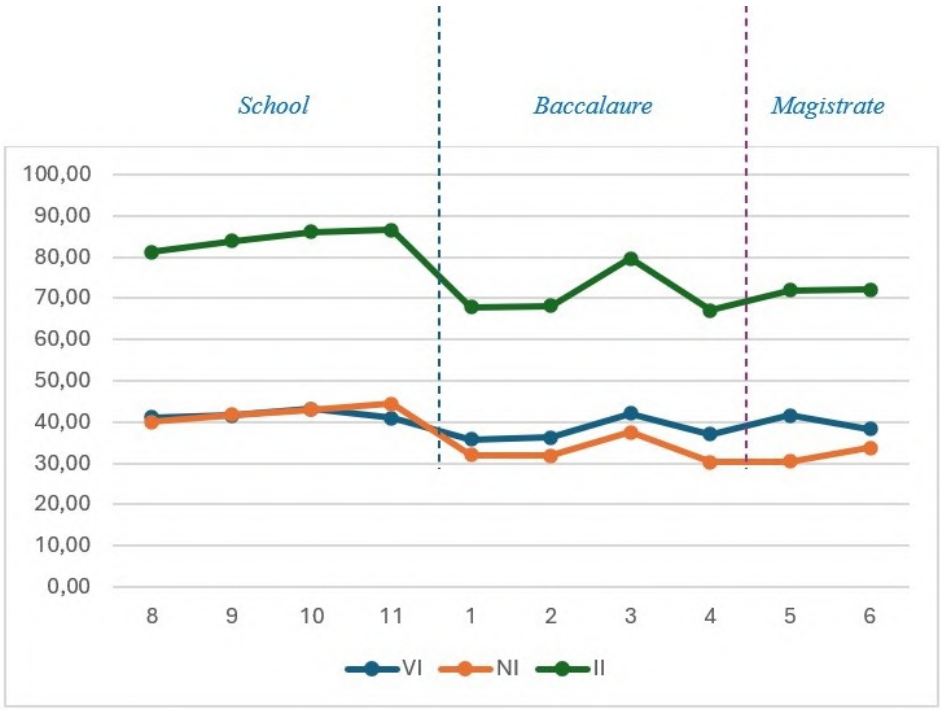

Figure 1: General intelligence changes by school and university years.

This result can be explained by the "bluring" of BD indices because of students entered the university on the base of academic skills, but not intelligence abilities. The MD level is a result of a special selection of BD students with abilities and achievements to research activity, in general case.

More detailed analysis of the intelligence structure has revealed that LS component (testing of language, ability to formulate judgments) demonstrates the highest level of developments from the 8th grad to the end of university learning (figure 2).

It is noteworthy that the WU (spatial thinking) indicator is the lowest for university students in all

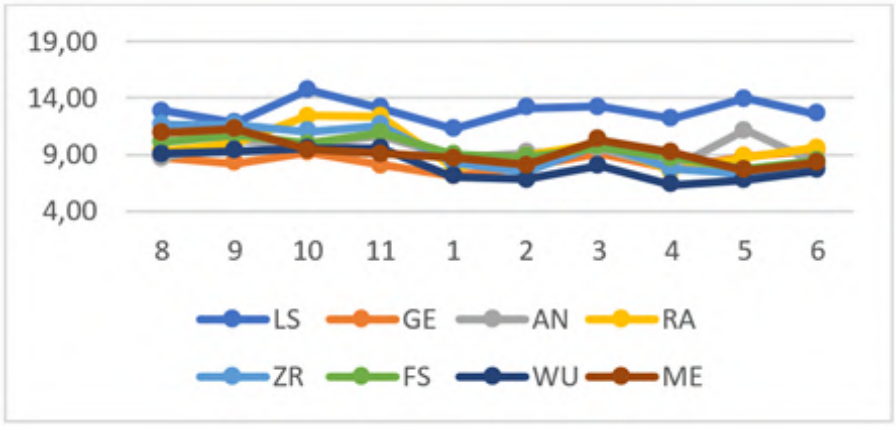

Figure 2: Intellect structure changes by school and university years.

years. Another dynamic have intelligence structure indices GE (conceptual intuitive thinking), AN (combinatorial abilities, mobility and ability to switch thinking), RA (ability to solve practical computational problems character) that increase in MD students, but are not significant in BDs. Component AN needs to be studied more particular in future, because it has a significant value in MD students of 1st year, but decreased in MD students of the 2nd year that was not expected and can be explained easily.

Importance of every intelligence component for professional skills is clear from the vector diagram where learners' and experienced professional IT specialists' indices are presented together (figure 3). As it was possible to expect, almost all intelligence components have higher values in professionals. But the conceptual intuitive thinking GE is slightly higher in MD students of the 2nd year. It should be noted, however, that this indicator varies little across all subject groups. What is noteworthy is that the working memory indicator of professionals is lower than in all other groups. This may indicate that for professional IT specialists, verbal memory as such is of less importance than abilities related to handling both non-verbal and verbal information.

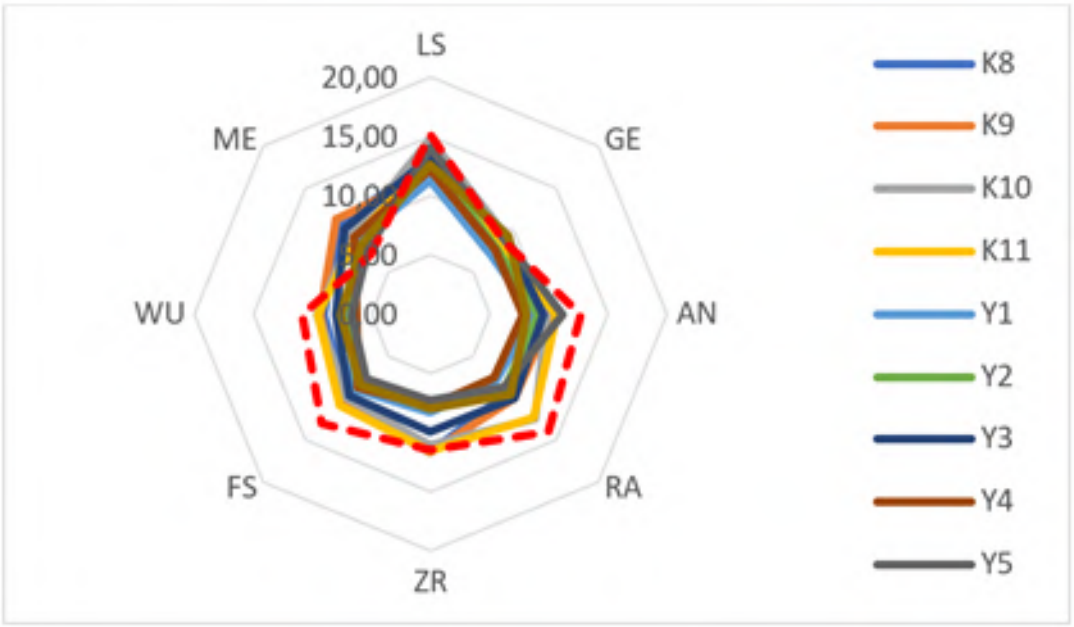

Figure 3: Intellect structure changes by IT-learners and IT-professionals.

The greatest difference between IT-professionals and IT-learners is manifested in ability to solve practical computational tasks RA and operation with spacial objects (FS and WU). This may indicate that these qualities are not so much developed during learning process, but are developed and trained during professional activity. In turn, this may serve as an indication to specialists in the teaching IT learners of the need to include special training of these professionally important qualities, possibly with the help of tasks for their non-specific development.

To analyze principal differences between school and university learners in the intelligence structure and balance of psychological qualities of learners, the forward stepwise discriminant analysis has been carried out (Statistica 6.0). The most significant indices were included into the discriminant model according to the criteria of the highest value of D^2-Makhalanobis factor. A significant difference has been revealed by two indices: WU (spatial thinking) indicator and GE (conceptual intuitive thinking) at the significance level $p < 0.001$. This fact corresponds data analyzed above, namely, their opposite dynamics: at school WU is better than at students, and GE vise versa. It looks like the GE index is trained in IT-learners over education period.

It is recognized by psychologists and educators that the education process forms human personality features in general, not only psychometric intelligence. To study their mutual influence, we analyzed correlation of measured personality trait indices with intelligence structure indices as well as balance

of psychological qualities over the high school and university learning period, because development of the individuum is not quick process and we expected that some personal features could have common relationship with professional development.

It was used the forward stepwise multiregression analysis to describe every psychological index from measured. Three steps selection allowed to evaluate the most informative indices. The results (table1) have shown that multiple correlation can be very high and significant. Only Pers' features perception P and thinking T did not have significant and high relationship with indices of Int and BPQ.

The most influenive index from BPQs for development of personality trait in IT-learners concentricity-eccentricity C turned out. At the same time, among intelligence indices, the index of combinatorial abilities, mobility and ability to switch thinking AN was important in relation to criterion scales orientation-of-consciousness E–I and decision-making F-T. It is possible to suppose that those indices could be professionally important qualities for IT professionals. That result corresponded earlier findings of B. Shneiderman [24] and could be used in planning of educational process of IT-learners.

Table 1
Relationship of personality and the most informative indices (Int+BPQ).

Personality index	The most informative indices	R	p < ...
N	C, WU, AN	0.89	0.01
S	ZR, C, BV	0.87	0.01
J	ME, BV, WU	0.73	0.2
P	BV, ME	0.6	0.1
I	WU, BP, C	0.89	0.01
E	BV, VK, C	0.82	0.05
F	C, H, AN	0.98	0.001
T	LS, AN, BP	0.81	0.1

5. Concluding remarks and future work

IT-related occupations are in the focus of the global economics and business. Many young people want to get appropriate education and job hoping to achieve success in life. Educators are actively involved in this expanding process and rely on their practical experience and digital tools. Almost all career guidance technologies, standards and approaches relate to technical or soft skills, but do not take into account that not all people can become the masters in IT domain because of some limitations of their abilities. Unfortunately, human psychophysiological abilities are often out of HRs' focus. That is why, we wished to study important abilities of IT-learners in projection on professionally important qualities of IT professionals from point of view of evolution (changes) of some intelligence and personality indices on the edge of a human transformation from adolescent to young adult as a future IT-specialist.

It has been revealed that the structure of intelligence can change at micro-age intervals over high school and university learning. However, the most popular view of researchers was a relatively stable level of intelligence after 15 years old. Besides, our research demonstrated a difference in that structure in high school pupils and university students even though all students studied in specialized classes or faculties and represented selective samples (vocational learning) independently on a particular organization of the education process of subjects.

Our findings allowed to propose educators to adapt educational process of IT-learners with regard to specific and/or non-specific training such professionally important psychological qualities as ability to solve practical computational tasks and operation with spacial objects (both 2D and 3D). However such interventions should be made about specifics of a particular educational institution, its education process organization as well as an individual style of student learning. Particular techniques and their implementation have to correspond to particular education environment's opportunities.

The tasks of relationship between structural components of intelligence and psychological features of a human personality trait can give deeper understanding of personality development in relation to IT professional skills and are planned for future study.

Some limitations of such a study are predefined by providing the online test performance to maintain equal opportunities for all subjects (observed persons) and comparability of test performance results.

References

[1] The Future of Growth Report 2024, Insight Report, World Economic Forum, Cologny/Geneva, 2024. URL: https://www3.weforum.org/docs/WEF_Future_of_Growth_Report_2024.pdf.

[2] European Union, EU4Digital: Connecting Research and Education Communities (EaPConnect), 2024. URL: https://eufordigital.eu/discover-eu/eap-connect/.

[3] Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution, White Paper, World Economic Forum, Cologny/Geneva, 2020. URL: https://www3.weforum.org/docs/WEF_Schools_of_the_Future_Report_2019.pdf.

[4] O. Burov, V. Bykov, S. Lytvynova, ICT Evolution: from Single Computational Tasks to Modeling of Life, in: O. Sokolov, G. Zholtkevych, V. Yakovyna, Y. Tarasich, V. Kharchenko, V. Kobets, O. Burov, S. Semerikov, H. Kravtsov (Eds.), Proceedings of the 16th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume II: Workshops, Kharkiv, Ukraine, October 06-10, 2020, volume 2732 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2020, pp. 583–590. URL: https://ceur-ws.org/Vol-2732/20200583.pdf.

[5] O. Y. Burov, O. P. Pinchuk, A meta-analysis of the most influential factors of the virtual reality in education for the health and efficiency of students' activity, Educational Technology Quarterly 2023 (2023) 58–68. doi:10.55056/etq.435.

[6] AI Alliance Governance: Briefing Paper Series, Technical Report, World Economic Forum, Cologny/Geneva, 2024. URL: https://www3.weforum.org/docs/WEF_AI_Governance_Alliance_Briefing_Paper_Series_2024.pdf.

[7] K. Jinyoung, P. Cyn-Young, Education, Skill Training, and Lifelong Learning in the Era of Technological Revolution, Asian-Pacific Economic Literature 34 (2020) 3–19. doi:10.22617/WPS200008-2.

[8] J. Stratton, The future of work starts with trust: How can we close the AI trust gap?, 2024. URL: https://www.weforum.org/agenda/2024/01/why-there-is-an-ai-trust-gap-in-the-workplace/.

[9] O. Y. Burov, O. P. Pinchuk, M. A. Pertsev, Y. Vasylchenko, Using the students' state indices for design of adaptive learning systems, Information technologies and learning tools 68 (2018) 20–32. doi:10.33407/itlt.v68i6.2715.

[10] O. Ovcharuk, I. Ivaniuk, O. Burov, M. Marienko, N. Soroko, O. Gritsenchuk, O. Kravchyna., The Practical Experience of the Use of Digital Learning Resources by Ukrainian Teachers to Ensure the Sustainable Development and Democratization of Education Process, in: Proceedings of the 1st Symposium on Advances in Educational Technology - Volume 1: AET, INSTICC, SciTePress, 2022, pp. 432–444. doi:10.5220/0010925000003364.

[11] S. Lytvynova, O. Burov, Methods, Forms and Safety of Learning in Corporate Social Networks, in: V. Ermolayev, N. Bassiliades, H. Fill, V. Yakovyna, H. C. Mayr, V. S. Kharchenko, V. S. Peschanenko, M. Shyshkina, M. S. Nikitchenko, A. Spivakovsky (Eds.), Proceedings of the 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer, ICTERI 2017, Kyiv, Ukraine, May 15-18, 2017, volume 1844 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2017, pp. 406–413. URL: https://ceur-ws.org/Vol-1844/10000406.pdf.

[12] O. Y. Burov, V. V. Rybalka, N. D. Vinnyk, V. V. Rusova, M. A. Pertsev, I. O. Plaksenkova, M. O. Kudriavchenko, A. B. Sahalakova, C. Y. M., Development changes of intellectual abilities of gifted person in teens, Infosystem, Kyiv, 2012. URL: https://lib.iitta.gov.ua/id/eprint/710058/.

[13] L. Yasyukova, Amthauer intellectual structure test (IST): Methodical Guidence, Imaton, 2002.

[14] S. Lytvynova, O. Burov, O. Slobodyanyk, The Technique to Evaluate Pupils' Intellectual and Personal Important Qualities for ICT Competences, in: V. Ermolayev, F. Mallet, V. Yakovyna,

V. S. Kharchenko, V. Kobets, A. Kornilowicz, H. Kravtsov, M. S. Nikitchenko, S. Semerikov, A. Spivakovsky (Eds.), Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume II: Workshops, Kherson, Ukraine, June 12-15, 2019, volume 2393 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2019, pp. 170–177. URL: https://ceur-ws.org/Vol-2393/paper_382.pdf.

[15] J. Piaget, Izbrannye psihologicheskie trudy, Mezhdunarodnaja pedagogicheskaja akademija, Moscow, 1994. URL: https://www.scribd.com/document/693388992.

[16] H. Gardner, Frames of Mind: The Theory of Multiple Intelligences, Basic Books, New York, 2011. URL: http://dspace.sxcjpr.edu.in:8080/jspui/bitstream/123456789/720/1/Howard%20Gardner%20-%20Frames%20of%20Mind_%20The%20Theory%20of%20Multiple%20Intelligences-Basic%20Books%20%282011%29%20%281%29.pdf.

[17] J. R. Flynn, Are We Getting Smarter? Rising IQ in the Twenty-First Century, Cambridge University Press, New York, NY, 2012.

[18] J. Pietschnig, M. Voracek, One Century of Global IQ Gains: A Formal Meta-Analysis of the Flynn Effect (1909–2013), Perspectives on Psychological Science 10 (2015) 282–306. doi:10.1177/1745691615577701.

[19] J. Pietschnig, M. Voracek, G. Gittler, Is the Flynn effect related to migration? Meta-analytic evidence for correlates of stagnation and reversal of generational IQ test score changes, Politische Psychologie 2 (2018) 267–283. URL: https://www.pabst-publishers.com/fileadmin/Redaktion/Beitrag_des_Monats/popsy_2-2018_267-283.pdf.

[20] E. G. Budrina, Dinamika intellektual'nogo razvitija v podrostkovom vozraste v uslovijah raznyh modelej obuchenija [Dynamics of intellectual development in adolescence under different learning models], Ph.D. thesis, 2005.

[21] O. S. Chalikova, Mikrovozrastnaja dinamika struktury intellekta podrostkov [Micro-age dynamics of the structure of intelligence in adolescents], 2002. URL: https://elar.urfu.ru/handle/10995/3978.

[22] B. G. Ananiev, Chelovek kak predmet poznanija [Man as an object of knowledge], Mastera psihologii, Piter, SPb, 2001. URL: https://platona.net/load/knigi_po_filosofii/psikhologija/ananev_chelovek_kak_predmet_poznanija/22-1-0-3830.

[23] V. Bodriakov, N. Fomina, Statistical processing of experimental data on the structure of students' intelligence of the Mathematics Faculty of the Ural State Pedagogical University as a basis for optimizing the educational process, in: Proceedings of the 2nd international scientific conference Information and Mathematical Technologies in Economics, Engineering and Education, UGTU, UPI, 2007, pp. 317–319.

[24] B. Shneiderman, Software Psychology: Human Factors in Computer and Information Systems, Little, Brown and Co, 1980.