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A Comparative Study of the Multiple Intelligence Profiles of First-Year IT Students and Employed Graduates

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Abstract. The aim of the article is to determine in the studied groups the multiple intelligence distribution defined in the 1980s by Howard Gardner. The research was conducted in three groups of respondents. The first study group was first-year students of computer science, the second was master (2nd degree) students, educationally 4 years older than the first group. Their intelligence distributions were compared with the intelligence distributions of the third group – graduates of the same university, the same field of study after several years of work in positions consistent with their education. Participants filled one of the multiple intelligence tests selected by answering 24 questions. A group of approximately 110 students and approximately 40 IT employees were examined. As there were statistically justified differences in several significant sub intelligences, a discussion was held on the forms of educational impact on student development paths. The research was carried out in conditions of full voluntary participation in the test and on the basis of self-assessment according to questions suggested in one of the online sources. According to the authors, the results seem interesting, although surprising.

Keywords: multiple intelligences, engineering education, student's personality, profile of intelligence, informatics.

Introduction

The authors present the results of research carried out in the environment of the university and business employing graduates of this university and this particular field of education with the intention of emphasizing both the importance and the opportunity to implement the results of the research. In the authors' conviction, the results can have strong practical significance. The conditions for their implementation are also described, which makes it possible to repeat them in subsequent student populations.

Multiple intelligences were fascinating prof. Howard Gardner as early as the 1980s. In a nutshell, this theory assumes the occurrence in every human being of many equal intelligence (sub intelligence) of varying strength (intensity) creating a specific, unique profile, changeable in time, representing developmental potential, especially for a child. Gardner after conducting numerous studies incl. (Gardner H., Hatch T, 1989) published his thoughts in the book (Gardner H., 1992), and then, twenty years later, evaluated their development and impact on the practice of education (Gardner H., 2003). The works of Howard Gardner, published, among others also in Polish (Gardner H., 2002) caused a great impact to the world of science, including recognition and criticism (Smith M.K., 2002, Battro A.M., 2010, Battro A.M. *et al.*, 2010, Silver H. *et al.*, 2000, David L., 2014). There have been proposals to extend the number of intelligences under consideration from the initial seven, after a few years to eight, to numerous, including spiritual, emotional, moral, sexual or digital intelligence. Especially the latest one, if its separateness can be justified by research results, should be of interest to the authors and the titular student population. Its significance seems to be constantly growing and it looks that this area of research is and will be a challenge for subsequent researchers.

Howard Gardner's theory of multiple intelligences is based on several basic theses formulated by its author:

1) We all operate with a full set (minimum) 8 intelligence – it makes us human.
2) Each person has a different intelligence profile (in each person the intelligences are developed in different ways) – even twins have different profiles.

Howard Gardner's vision can be exposed by his metaphor that compares the human brain to a set of computers (Gardner H., 2003). One can imagine the brain as a network of relatively independent computers specialized in solving specific tasks.

These "computers" are responsible for tasks in various areas of human activity, such as (the order of the following intelligence is not imposed, please remember that they are equally important):

- Naturalistic.
- Logical-Mathematical.
- Linguistic-Verbal.
- Musical.
- Visual-Spatial.
- Bodily-Kinesthetic.
- Interpersonal.
- Intrapersonal.

These are obvious Gardner's intelligences which can be described precisely as below (by Silver H. *et al.* 1997 and Kendra Cherry, 2019):

Naturalistic intelligence

This type of intelligence is based on cognition, appreciating and understanding nature. A person with natural intelligence "feels" nature, cares for the world, cares for animals, cares for plants. The person has the ability to understand and draw conclusions and benefits from the environment. Examples of professions characteristic of this type of intelli-

gence are e.g. cynologist, botanist, veterinarian or farmer. Children with well-developed naturalistic intelligence are great at classifying various subjects in the hierarchy (they grade more important and less important things), they see patterns functioning in nature. Children – naturalists actively spend time outdoors, like trips, picking mushrooms, collecting leaves.

Logical-Mathematical intelligence

Intelligence so present in nowadays schools and so important not only in education but also in adult life. Its importance for the development of societies is very important.

This kind of intelligence is based on cause and effect thinking. It appears in perceiving the world through series of events, logical thinking. So far, popular IQ meter research has focused on this type of intelligence.

People with this type of intelligence use logic, numbers, schemes, and can easily recognize the relationships and connections between information. Things that have no logical sense are worthless to them. They tend to think abstract and conceptual. They are inquisitive, systematic and accurate. They think easily and behave in an orderly, algorithmic way. During school classes, they like to ask questions. They are well organized and use logical arguments. These skills are extremely important for mathematicians, IT specialists, bankers, physicists, chemists, medical doctors and engineers. A teacher of mathematics and programming in high school and college refers to this kind of intelligence. It is indispensable in studying mathematics, computer science, telecommunications and their application in all IT professions and specialties.

Linguistic-Verbal intelligence

It is a skill to use words and language freely. People with verbal intelligence carefully choose words because they are able to pick up subtle differences in meaning between words, have a sense of rhythm and sound of words. They have a rich vocabulary, they are happy to use synonyms. They use words for entertainment, information or persuasion. They like literature, play with words, willingly take part in debates, are good at writing work. They learn another foreign language more easily than others. Due to these skills, they work well in the profession of writer, journalist, journalist, lawyer, teacher and translator.

Musical intelligence

This type of intelligence appears as the earliest. Musical children like to sing, hum, play any musical instrument and thing they can, they just surround themselves with music and sounds. Musical intelligence is easy to develop by combining daily activities with music: listen to music while doing housework, sing, hum, rhyme, take your child to concerts and walks in the park, encourage public performances and composing. It is possible to subscribe a child for classes in rhythm, singing or playing an instrument. In adult life, this intelligence is revealed by a love of music, the search for good and favorite music, also the ability to play musical instruments. The professions associated with this intelligence are quite obvious.

Visual-Spatial intelligence

This kind of intelligence makes possible to understand the surrounding thanks to shapes and images coming from the outside world and imagination.

A person endowed with this type of intelligence "thinks with images," or uses the imagination. The child pays attention to details, everything is important to him. They are characterized by high sensitivity to surrounding objects, colors and patterns. He likes to do various kinds of artwork, arranges puzzles, read maps, knows how to combine colors harmoniously. He is an observer, he often uses his imagination – visualizations, he eagerly depicts issues in the form of diagrams, schemes and tables. He engages all the senses in the process of remembering. A child with developed spatial intelligence is very creative. Children with developed visual-spatial intelligence have a rich imagination, they prefer books with many illustrations, they cope well with puzzles, blocks and construction toys. In adulthood, this type of intelligence is useful in many professions related to imagination and space. It can be a road and bridge engineer, computer graphic designer, architect, filmmaker but also a poet, naturalist, cartographer.

Bodily-Kinesthetic intelligence

Children with bodily-kinesthetic intelligence love dance and sport. They are happy to do various types of work by themselves, e.g. DIY, carving. Every day they use body language and make a lot of gestures. They can perform difficult maneuvers, without using logical and conscious thinking, both with their own body and other objects. They have perfectly developed automatic reactions. They can plan activities, share tasks, have great spatial organization. Children with this type of intelligence are fond of movement games, preferably group games. Adults mistakenly call them "hyperactive". Such children are very sensitive to touch. Schoolchildren with developed bodily-kinesthetic intelligence often have problems at school because they are expected to focus and quiet, or simply sit at the bench. They should be provided as many breaks as possible. Classes for such children should be varied, interesting, using different types of equipment (e.g. microscopes, projectors, interactive boards). They remember most easily what was done, and harder what was only discussed. In adulthood, this type of intelligence is primarily found in athletes who were diagnosed with these benefits in childhood. It is also the intelligence of craftsmen who make movement and sculptors, drivers and pilots.

Interpersonal intelligence

People with this type of intelligence simply have to be surrounded by people. They learn through interpersonal contacts. They can be excellent listeners and advisers. They have wide interests and often attend many additional activities. Critical opinions only motivate them to act. Children with well-developed interpersonal intelligence are assertive, communicative, easily establish and maintain social contacts, are able to cooperate, have leadership skills and mediation skills. They are characterized by easy learning, understanding of thoughts, feelings, views and behaviors of other people, they are tolerant. In professional life, it is the intelligence that dominates politicians, senior officials, teachers, travel guides, lawyers and priests.

Intrapersonal intelligence

People with developed intrapersonal intelligence have so-called "Life wisdom", intuition, internal motivation and a strong will to act. Such people are somehow secretive, they prefer to work alone, they can be shy.

Children with strong intrapersonal intelligence are individualists, they are responsible, they know their strengths, they build internal motivation. They are not afraid of difficult questions and are willing to take risks. They like to know the opinions of others, which they then analyze, broadening their horizons of thinking. They do not give up their ambitions and do not dwell on failures and weaknesses.

The best way to develop a child with a well-developed intrapersonal intelligence is to create optimal conditions in which he himself determines the scope of work and the pace of work. Such a child must be able to experience self-study. Looking for "his" place. An adult with such intelligence is often a type of researcher, thinker, philosopher, writer, but also a computer scientist, mathematician, poet, naturalist and traveler working alone. The occurrence of this kind of intelligence among programmers who prefer to immerse themselves in their thoughts in search of innovative algorithmic or programming solutions should not surprise.

In the article, the authors use the following terms interchangeably – multiple intelligences, partial intelligence and sub intelligence to describe the same concept. As mentioned, similar types of intelligence can be more. That's what initially proposed prof. Gardner. He was criticized for his lack of in-depth scientific research to extract these intelligences. Instead, Howard Gardner based his own intuition. In addition, some believe that these intelligences are simply our talents and our distinguishing abilities (Smith M., 2008, David L., 2014). Others believe that Gardner confuses or does not include learning styles in its classification (Terada Y., 2018).

Many years of practical application of Gardner criteria justify their motivational strength. After conducting research, this view is also shared by the authors of this work.

The article is organized as follows. After the introduction, the authors discuss research methodologies by reviewing the tests proposed by various authors. Next they present the selected test, the method of collecting answers and normalization of the results. The next three chapters discuss research carried out successively on a group of first-year students, on a group of second-degree students of computer science, four years older than first-year students, and on a group of IT company employees. The tests are illustrated with polar charts and histograms enabling visualization of test results. The article ends with conclusions and a bibliography.

Review and Selection of the Test for Further Research

Multiple intelligence tests are most often not scientifically defined and standardized. There are many Gardner multiple intelligence tests available. The tests differ in a form (tests to be completed in a computer or in writing on paper), the number of questions,

the method of marking answers (marking the appropriate question or evaluating each question on a specific scale), precising the questions for a specific age group. Many tests can be found on the Internet, which in most cases are treated as fun based on the subjective assessments of participants. It happens, that the test is well-calibrated, gives a large spread of results and can be important for provoking reflection and motivating the respondent. Here are some examples.

One of the available tests based on paper filling is the test prepared by Chislett V. and Chapman A. (2006) available on the Internet on the Businessballs e-learning site "Multiple Intelligences Test – based on Howard Gardner's MI Model".

This is a four-page paper version for self-filling. The test consists of 70 questions marked with blue or red. Respondents in the 8–16 age group should answer only questions in red, while for the group of respondents over 16 years of age there are additional blue questions.

The authors of the test have provided two options for answering: by checking the box next to the question that fits the respondent (with the intention of translating this method of filling the form into his speed of answering the question) or by giving appropriate weight in gradations from 1 to 4, where 1 means disagreeing with a question, while 4 full compliance.

The results are determined by counting the correspondingly marked fields by adding up the occurrence of the marked field in a given column or, in the case of evaluation of answers, by adding the value assigned to each question in a given column.

The analysis of results requires manual work and introduces the possibility of making a mistake when digitizing the results caused by a human factor.

Another example of the test can be found at `literacynet.org`.

It is a test developed by Terry Armstrong in the form of an online form consisting of 56 questions. The questions are numbered, each question has 5 single-choice fields with an assigned value corresponding to the scale. The scale is in the range from 1 to 5, where 1 means that the statement does not describe the respondent completely, while 5 means the exact description of the respondent.

The completed form is confirmed by pressing the button below the form. The user then has 5 intelligence results available. For the top 3 intelligences with the highest score, there is a description of the type of intelligence and activities appropriate for the given intelligence. The summary includes the numerical result for 5 intelligences.

Another example is a test developed by Marsh Fralick in the form of a paper form (`https://www.collegesuccess1.com/InstructorManual4thEd/Learning%20Style/MI_quiz.pdf`). The questions are grouped into blocks of 8 questions for each of the 8 intelligence examined. This test differs fundamentally from those described in the comparison in that in the case of this test the respondent is aware of what intelligence evaluates at the time of the answer, while in the remaining tests the answers were not grouped and the respondent did not know what intelligence the specific question was about. In addition, this test distinguishes an imposed maximum time of 20 minutes to complete the response. The answers are placed on the value function chart (intelligence type). Answers are given on a scale of 1 to 5, where 1 means complete disagreement, while 5 means complete agreement.

Such tests can be found on the Internet, especially in situations where the teacher approaches the results with caution and caution and knows how to apply them properly in educational practice.

For the purposes of this article, the authors used the test developed by Polish teachers Beata Cias-Smutek and Grazyna Kaminska from Primary School 22 from Kielce as part of the international project "Sharing our treasures for a better future". The project was inspired by American teacher Laura Candler (lauracandler.com).

Test will be described in a further part of this publication.

Research Methodology

The first study was conducted in the first year of computer science at the Koszalin University of Technology in March 2019 using the said test, maintaining the anonymity of students. It is worth noting that the research is conducted on a fairly large sample of 71 students. Howard Gardner in his initial research was also based on the results of smaller student groups, e.g. at work (Gardner, H., Hatch, T. (1989), the authors mention groups of 20 people).

The research was carried out on the test chosen by the authors described on the page (`sp22.kielce.eu/zawartosc/inteligencji-wielorakie`). Access to the test under the "Test" button. This test was created as a result of international cooperation under a project also carried out by a group of teachers from the Primary School in Kielce, Poland with a view mainly to students. After attempts by the authors of the article with several other tests, this one was chosen because of the advantages noted – it required relatively little time and gave a good, differentiated distribution of results in individual intelligence categories. The test is considered as well-calibrated.

The test was carried out at the university as part of one of the subjects related to the social aspects of the profession of information technology. Students in groups of 15–20 people were invited to the laboratory where they obtained access to the .xls worksheet containing questions at computer workstations. The surveys usually took 5–12 minutes to complete. After completing the test, the vector of answers along with their identification number were saved by students in a dedicated file on the computer's desktop, sharing this data with research organizers. This mode allowed for relative anonymity.

The use of the term "relative anonymity" results from knowledge of the studied group of students – students partly know each other, although this is not common, they can guess their identities, but they do not know the results of surveys carried out in neighboring positions or in other groups of respondents. Therefore, the authors believe that the attempt to anonymize the results is completely sufficient and effective in the psychological aspect. The considered traits of students are certainly not sensitive data, they are obtained in conditions of self-assessment and voluntariness and were passed on by some of them carelessly, without particular attention to the purpose of the research. On the basis of the author's observations, it can be assessed that such behaviors, undesirable from the point of view of caring about the objectivity of results, were rather rare and did not exceed approx. 3–5% of the total number of respondents.

The survey was made available to students in the form of a Microsoft Excel spreadsheet (XLS file format) containing exactly the same questions that were proposed in the source (sp22.kielce.eu/zawartosc/inteligencji-wielorakie).

It is a set of 24 questions or statements (to assess their adequacy for the respondent), which in a camouflaged manner (of course, superficially) are associated with individual prof. Gardner's multiple intelligences. In axiological terms, the survey is to be a platform for the respondent's spontaneous, quick responses, not a place of meticulous analysis, which the author of the survey intended to ask the student about. From this point of view, the organizers encouraged students to respond quickly. Here is the content of the survey in accordance with (sp22.kielce.eu/zawartosc/inteligencje-wielorakie) – translated into English.

	Which of the following applies to you?	0–5
1	I like to sing and I sing well.	0
2	I love crosswords and other word games.	0
3	I like spending time alone.	0
4	Charts, maps, graphics tables help me learn.	0
5	I learn best when I can discuss new issues.	0
6	I like art, fine arts, photography and handwork.	0
7	In my free time, I often listen to music.	0
8	I live well with people of different characters and interests.	0
9	I often think about my goals and dreams related to the future.	0
10	I like learning about the Earth and nature.	0
11	I enjoy looking after domestic and other animals.	0
12	I like tasks related to physical movement and role-playing.	0
13	Written essays are usually easy for me.	0
14	It's easy for me to learn new math material.	0
15	I play or would like to play a musical instrument.	0
16	I am good at physical activities such as sports or dancing.	0
17	I like number games and logic puzzles.	0
18	I learn best when I can do practical exercises.	0
19	I love painting, drawing or designing something on the computer.	0
20	I often help others on my own initiative.	0
21	Regardless of the weather, I like to be outdoor.	0
22	I love the challenge when you have to solve a difficult math problem.	0
23	Peace and quiet during learning and reflection are important to me.	0
24	I read for pleasure every day.	0

Students overwhelmingly completed the survey easily, without additional questions, and mostly interested in the results of future comparisons and the results of student responses). For each of Gardner's eight intelligence (also referred to as subintelligence) three questions were answered, the student was not supposed to know which. Thus, after assigning each subintelligence three questions out of twenty-four, eight quantitative intelligence characteristics were obtained for each student.

Students could rate questions on a scale of 0–5, and thus get a total score from 0 to 120 points If the student rated all suggestions at zero, he would obtain the final result in

the form of a vector of eight zeros for eight of his individual intelligence, if he answered all questions with a grade of 5, he would obtain a result in the form of a vector of eight scores of 15 points for each subintelligence.

These results were then normalized to the range [0,1] by dividing by the potential maximum value three answers, i.e. by $\max(c_j) = 15$:

$$C_{ij} = c_{ij} / \max(c_j) \quad (1)$$

$i = 1, 2, \ldots, M$ – students reference number;
$j = 1, 2, \ldots, 8$ – sub intelligence reference number

Where $\max(c_j)$; $j = 1, 2, \ldots, 8$ maximum value assesed by the student in test for each of the intelligence, in this case equals 5.

In this way C_{ij} normalized answers were obtained, each in the range [0,1], $i = 1, 2, \ldots, M$ (number of students); C_{ij} $j = 1, 2, \ldots, 8$ (number of subintelligences).

As already mentioned, comparative studies were also carried out in two other groups. The first was a smaller group of second-cycle computer science students (older than the first-year first-year study group by 7 semesters) and a group of IT sector employees in the same city consisting mostly (82%) of graduates from the same faculty and the same field of study – computer science technical support. The strategic goal of the research was to discover the direction of changes in student sub intelligence in the direction of the desired desirable states of sub-intelligence distribution among IT sector employees. If significant differences were found as a result of the research in intelligence profiles, assuming that the profiles listed on the labor market are correct, didactic development paths enabling profile convergence should be considered.

Research among IT sector employees was carried out at a selected large IT company employing many graduates from a local university. They were carried out according to a slightly different methodology for obtaining answers. Test has been performed during business hours from May 7 to May 10, 2019. The company's employees were notified by e-mail about the purpose of the study and the form together with a link to the form. The form of the study was questions with 6 single-choice fields for each question in Google Forms. In addition, the last question indicates whether the respondent is a graduate of the Koszalin University of Technology. The answers provided were automatically collected in a spreadsheet, which made it possible to eliminate erroneous data entry caused by human factors if the test were in paper form. Each respondent could complete the form only once. Participation in the study was voluntary. Only technical employees took part in the study, people employed in non-technical departments did not participate. Access to the survey was possible after authentication using the corporate Single Sign-On solution. The scale of matching answers to respondents ranged from 0 to 5:

- 0 – it doesn't suit me at all.
- 1 – definitely not.
- 2 – rather not, this is rarely true.

- 3 – sometimes it's true.
- 4 – rather yes, often.
- 5 – definitely yes.

All achieved results were calculated and visualized.

Test results in a group of first-year students

The test results for each examined group were collected in the form of the Cij matrix with the dimensions M × N, where i = 1, 2, ... M are matrix rows containing data of subsequent students / employees from the first to the last with the row number, for the first year group M = 71. Each row contains j = 1, 2, ..., N; N = 8 student characteristics (subintelligence). According to Gardner's suggestions, these intelligences (Gardner H., 2002) were numbered j:

1. Naturalistic.
2. Logical-Mathematical.
3. Linguistic-Verbal.
4. Musical.
5. Visual-Spatial.
6. Bodily-Kinesthetic.
7. Interpersonal.
8. Intrapersonal.

These results were placed in the Matlab environment. Basic and interesting statistical calculations were made according to the authors. First of all, the average value of individual partial intelligence was calculated for the whole year.

The results in the form of a histogram are shown in Fig. 1.

The histogram from Fig. 1 indicates rather unexpected dominance of intrapersonal intelligence, to which the authors will return in their conclusions. According to the authors, the most desirable for students of technical informatic – Logical-Mathematical intelligence – is not impressive here. This is intelligence number 2 in the figure, it only ranks at the fifth place among Gardner sub intelligence.

The mean values and standard deviations for all eight sub intelligences in turn for the entire studied group of students were (mean m = 1.0 would mean that all students rated themselves as the maximum in the given sub intelligence range):

$$m_j = [\ 0.5803\ \ 0.6563\ \ 0.5296\ \ 0.6657\ \ 0.6131\ \ 0.6808\ \ 0.6742\ \ 0.7944\ ];$$

and their standard deviation s_j for j =1,2, ..., 8 equals:

$$s_j = [\ 0.2103\ \ 0.2113\ \ 0.1974\ \ 0.2238\ \ 0.2317\ \ 0.1955\ \ 0.1704\ \ 0.1269\ ];$$

Based on the m_j vector – the position of m_2 (Logical-Mathematical) intelligence can be seen against the background of other student sub intelligence.

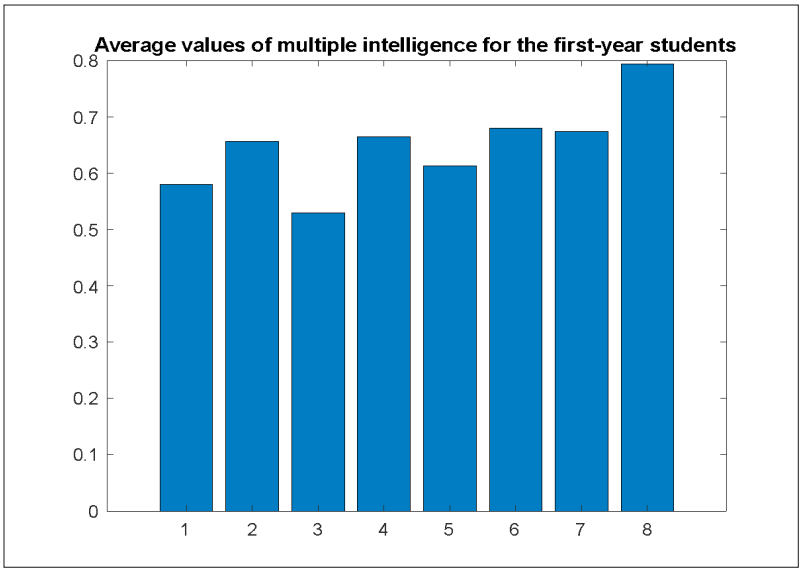

Fig. 1. Average values of partial intelligence for the first-year student group, in order: 1. Naturalistic, 2. Logical-Mathematical, 3. Linguistic-Verbal, 4. Musical, 5. Visual-Spatial, 6. Bodily-Kinesthetic, 7. Interpersonal, 8. Intrapersonal.

Of course, the researcher's interesting question is whether the observed partial intelligence differs statistically justified and whether there are correlations between them.

Significance test was used for two means – primarily for two key intelligence – the second, Logical-Mathematical, and the last, eighth – Intrapersonal. A null hypothesis was made about the equality of these means $H_0 : m_2 = m_8$.

It was assumed that standard deviations for both test vectors are calculated on the basis of tests and are different. For the test, normal distribution was also assumed in both samples.

The test of significance of the hypothesis for two means was carried out assuming that the standard deviations in the compared samples are different (Bruce, P., Bruce, A. (2017)).

The significance test was carried out using the matlab function *ttest2* with the parameters *ttest2* (x, y, 'Vartype', 'unequal') where:

x – is a vector of student self-assessments for Logical-Mathematical intelligence x_j for j = 1, 2, ..., N (where N = 71 and the number of students participating in the experiment;

y – is a vector of student self-assessments for intrapersonal intelligence y_j for j = 1, 2, ..., N (where N = 71 and the number of students participating in the experiment.

Parameters 'Vartype' and 'unequal' mean respectively variable, calculated significance level and inequality of variance (here in vector si is observed significant differences in standard deviations.

After execution of the *ttest2* function, the result h = 1 was obtained, which means the possibility of rejecting the null hypothesis of mean equality with a very low probability of making the first type of error (rejection of the hypothesis if it were true). So, it was statistically confirmed what intuitively seems obvious – the means are rather different. Analogous it can be checked hypotheses regarding differences between other means. On the other hand, they are not so important for the assessment of a group of students. The most important conclusion of this fragment of research is that first year students of computer science have the most developed Intrapersonal intelligence and it is statistically greater than desired, according to the authors, Logical-Mathematical intelligence.

An interesting result is a review of the distribution of all student intelligence of the whole year on one chart. To visualize this distribution, the matlab's polar function was used, enabling the presentation of multidimensional space in the form of a polar chart, on which the distance from the center of the chart determines the value of the variable and individual variables (here – partial intelligence) are presented radially, at a certain angle of a full circle. In a given case – eight variables – partial intelligence, the full 360 degree angle was divided into sectors of 45 degrees, which allowed the presentation of eight variables (partial intelligence) without putting the last variable on the axis initiating the graph – presented in Fig. 2.

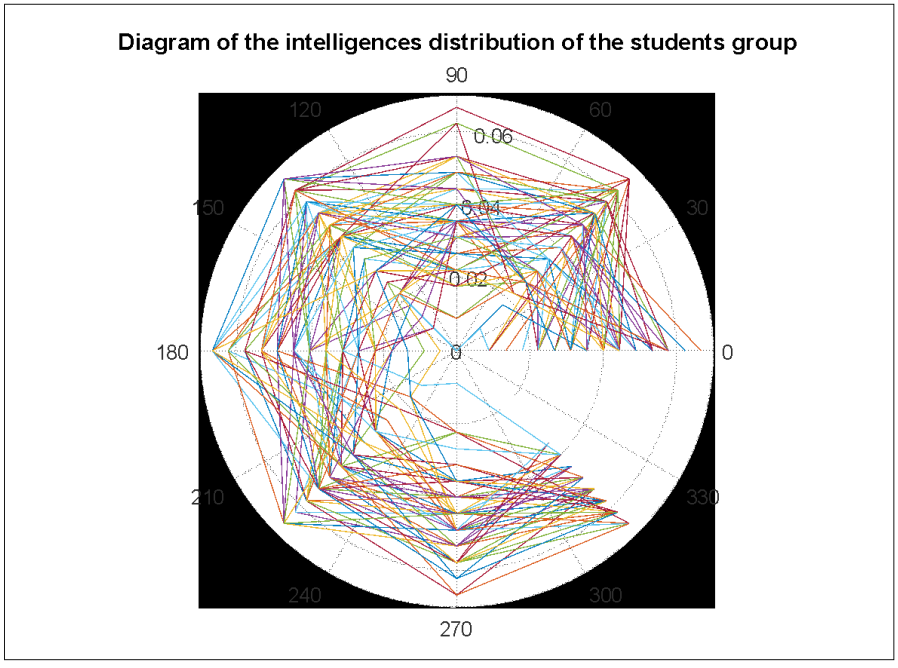

Fig. 2. Polar chart of partial intelligence profiles of 71 first-year students of computer science. On the chart, in order: at 0 degrees – Naturalistic; 45 degrees – Logical-Mathematical; 90 degrees – Linguistic-Verbal; 135 degrees of Musical; 180 degrees – Visual-Spatial; 215 degrees – Bodily-Kinesthetic; 270 degrees – Interpersonal; 315 degrees – Intrapersonal.

Visualization of the sub intelligence distribution throughout the year in Fig. 2 confirms the superficial assessment of the correctness of the test used. It is observed uniform saturation of the entire chart with student self-assessments, without special densities or empty fields.

In this part of the research, considering that some competences of first-year IT students are insufficient to meet the expectations of the labor market, attempts have been made to influence the student community. Interpersonal sub intelligence, which can be shaped by motivating students for mutual interaction, conversations, meetings, exchange of views and joint actions, was considered relatively easy to define the goal of interactions. A way of influencing this sub intelligence of students was also the appropriate use of research, by extracting from the test results the appropriate projections, e.g. individual student results against the background of a group, against the background of several people, against the background of averages, etc.

After studying Gardner's work, it is worth mentioning his efforts to search for people with a rich diverse personality expressed by large deviations of partial intelligence from the average intelligence in the group. Gardner and his doctoral student Hatch (Gardner, H., & Hatch, T. (1989)) examined e.g. the indicator how many times the examined person crosses the $bi = mi + k\ s_i$ barrier up or down; or $bi = mi - k\ s_i$; for i = 1,2, ..., 8;

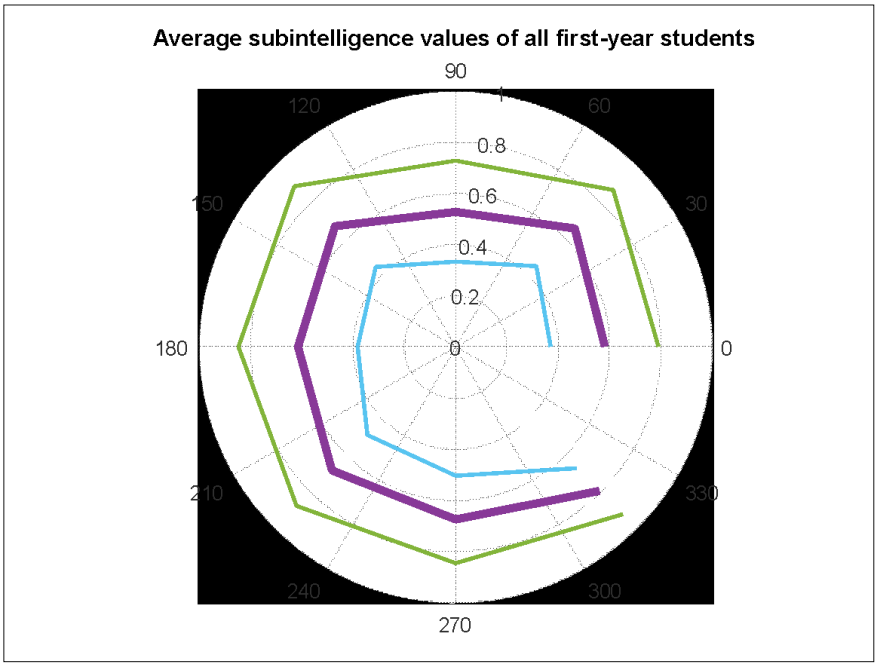

Fig. 3. A polar graph showing mean intelligence values (thicker curve in the center) placed between two curves symbolizing standard deviation added and subtracted from the mean. On the chart, in order: at 0 degrees – Naturalistic; 45 degrees – Logical-Mathematical; 90 degrees – Linguistic-Verbal; 135 degrees of Musical; 180 degrees – Visual-Spatial; 215 degrees – Bodily-Kinesthetic; 270 degrees – Interpersonal; 315 degrees – Intrapersonal.

where k – gain factor of distance from the mean. Gardner considered the multipliers k = 1 and k = 2.

The same was done in the research presented here. For 20 people participating in the study, Gardner found one that was in the range $k = +/- 1$ without exceeding any of his intelligence within the range close to means, i.e. not more than one standard deviation.

Similar research carried out in a group of computer science students found:

5 out of 71 people with their partial intelligence in the range of $+/- s_i$, for $i = 1, 2, ..., 8$, and 17 out of 71 people remaining with their partial intelligence (at least one) outside the range $mi +/- 2s_i$, for $i = 1, 2, ..., 8$.

Fig. 3 presents in the form of a polar chart the average values of partial intelligence for the entire year of computer science students and the band formed after adding and subtracting the standard deviation from this average.

Given the first attempt, the ratio 1/20 is close to 5/71. The results are therefore similar to those obtained by a classic.

Students were very interested in their own intelligence profile imposed on the means for the whole group. Such a chart is presented in Fig. 4. Information whether one is above or below the average for the whole year seems to be motivating and valuable in terms of personal development. The figure shows the student profile, which for five intelligence has an individual value above the average for the year, for two – below and once it is at the average level.

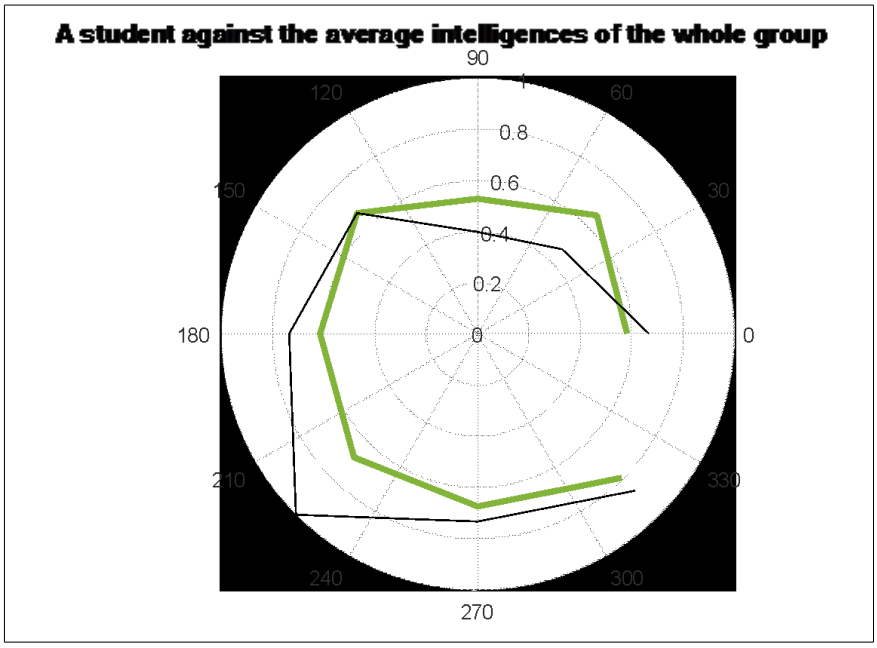

Fig. 4. Student profile against the background of average intelligence values throughout the year (bold curve). On the chart, in order: at 0 degrees – Naturalistic; 45 degrees – Logical-Mathematical; 90 degrees – Linguistic-Verbal; 135 degrees of Musical; 180 degrees – Visual-Spatial; 215 degrees – Bodily-Kinesthetic; 270 degrees – Interpersonal; 315 degrees – Intrapersonal

Another element of the study were classes with students presenting selected results of intelligence calculations. After presenting a few diagrams, students read their strengths and weaknesses and asked for comparisons with others. The condition of participation in this type of game was the consent of the interested parties themselves and consent to the presentation of their profiles to the whole group. An example of such two compared profiles is shown in Fig. 5.

The greatest interest aroused the search for students with profiles closest to the indicated person. It was an interesting experience because the students did not know each other very well for various reasons. Firstly, because it is the first year, often participating in classes divided into smaller groups, secondly, it is a new feature of this generation of millennials immersed in the virtual reality of smartphones, games, applications.

The following rules have been applied here. Any student wanted to stay anonymous in the auditorium could reserve it and his name would be replaced with a nickname. This provision of privacy was necessary because it was difficult to predict which names would be shown on the screen as those with the profiles most similar to the profile of the student being considered. Then, a student interested in learning about "closest" to himself in terms of intelligence profiles approached Matlab program used the following search formula:

Matrix of "distance" between student profiles $D = d(i,j)_{NxN}$

"Distance" between two students i-th and j-th:

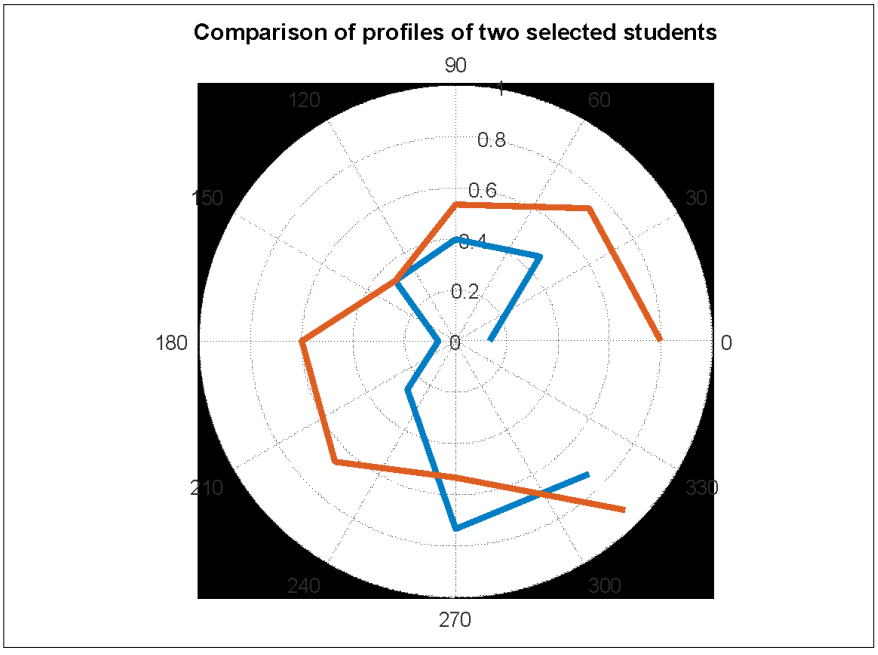

Fig. 5. Comparison of partial intelligence distribution of two selected students. On the chart, in order: at 0 degrees – Naturalistic; 45 degrees – Logical-Mathematical; 90 degrees – Linguistic-Verbal; 135 degrees of Musical; 180 degrees – Visual-Spatial; 215 degrees – Bodily-Kinesthetic; 270 degrees – Interpersonal; 315 degrees – Intrapersonal.

$$d(i,j) = \sum_{k=1}^{8} |x_{ik} - x_{jk}| \quad (3)$$

where:

x_{ik} – value of k-th partial intelligence of i-th student;

x_{jk} – value of k-th partial intelligence of j-th student;

After determining the "distance" matrix between the students and selecting the student (the student interested in finding the most similar colleagues in terms of intelligence), the students were sorted. If the student concerned had a number, e.g. iD, sorting took place in the iD column of matrix D from the smallest $d(iD, j)$ to the largest $d(iD, j)$, for $j = 1, 2, ..., N$. From the vector created in this way in increasing distance k first (nearest) cases were selected according to the title name of the kNN method (k Nearest Neighbors).

There has been displayed a diagram on the screen as in Fig. 6, and in addition the names of the students (if they agreed).

This fragment of the presentation of research results aroused the greatest interest of students. More than half of the students participating in the classes got acquainted with their "neighborhood".

Further studies with first-year students were carried out after obtaining the results of the test carried out at the selected IT company.

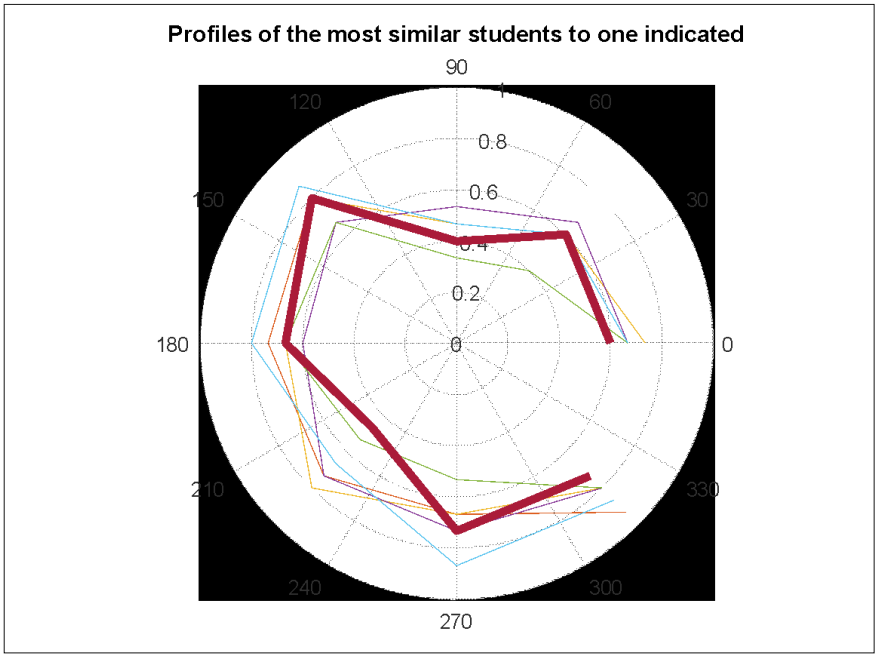

Fig. 6. Profile k = 5 students most similar in terms of multiple intelligences to a student with a profile marked in bold. In order: at 0 degrees – Naturalistic; 45 degrees – Logical-Mathematical; 90 degrees – Linguistic-Verbal; 135 degrees of Musical; 180 degrees – Visual-Spatial; 215 degrees – Bodily-Kinesthetic; 270 degrees – Interpersonal; 315 degrees – Intrapersonal.

Research conducted in a group of IT sector employees

Research is based on the same test that was carried out in one of the representative companies in the IT sector in Koszalin (the same city where the students undergoing the test and described the above study). The authors have the right to say about the company only that it is a leading entity in the region, which is part of a global corporation, has a carefully selected staff, applying good practices. From this point of view, it is difficult to find a better pattern of the IT environment on the labor market in terms of comparing the intelligence of the staff with the intelligence of students. The second author is an employee of this company and PhD student of the Technical University of Koszalin.

The research carried out in this company gave the results of the test, whose histogram of average values is shown in Fig. 7.

The detailed distribution of means and standard deviations for the histogram in Fig. 7 was as follows:

Average values of partial intelligence in a group of employees:

$$m_{ie} = [\ 0.6963 \quad 0.7796 \quad 0.5611 \quad 0.5944 \quad 0.6259 \quad 0.6222 \quad 0.7611 \quad 0.7815\ ];$$

and their standard deviation from the sample s_i for $i = 1, 2, ..., 8$ equals:

$$s_{ie} = [\ 0.1464 \quad 0.1911 \quad 0.1813 \quad 0.2517 \quad 0.2327 \quad 0.1731 \quad 0.1327 \quad 0.1492\ ];$$

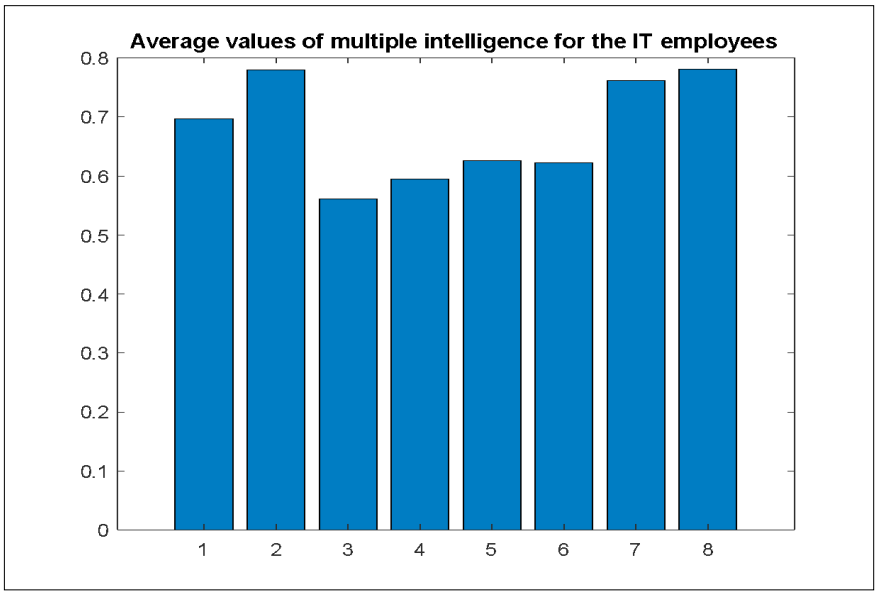

Fig. 7. Histogram of the intelligence distribution of partial graduates – IT sector employees a few years after graduation; in order in order 1 – Naturalistic; 2 – Logical-Mathematical; 3 – Linguistic-Verbal; 4 – Musical; 5 – Visual-Spatial; 6 – Bodily-Kinesthetic; 7 – Interpersonal; 8 – Intrapersonal.

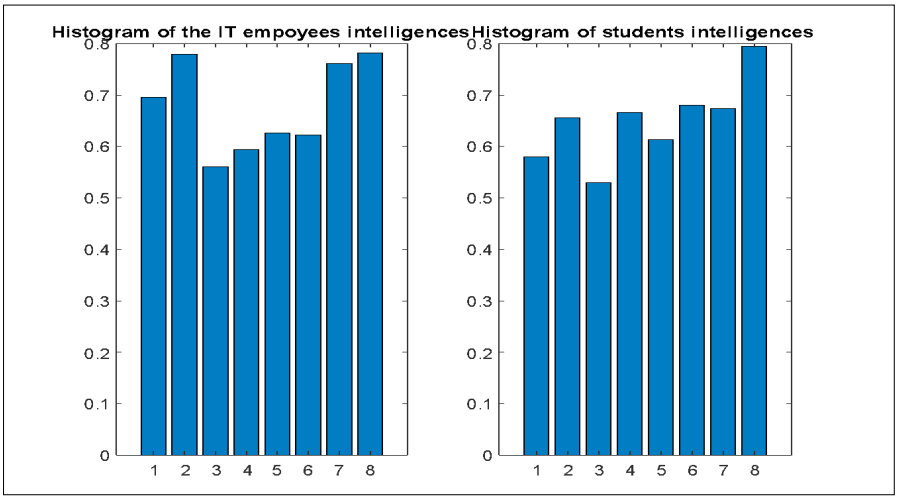

Fig. 8. Histograms of partial intelligence of employees and students; in order 1 – Naturalistic; 2 – Logical-Mathematical; 3 – Linguistic-Verbal; 4 – Musical; 5 – Visual-Spatial; 6 – Bodily-Kinesthetic; 7 – Interpersonal; 8 – Intrapersonal.

There are significant differences between these distributions. To make them better visible, the histograms are placed next to each other – Fig. 8.

A drawing was also made showing the differences between the distribution of employee and student intelligence – Fig. 9 and Fig. 10.

Fig. 9 presents a histogram of the differences between employee and student intelligence $dI_i = Ie_i - Is_i$, for $i = 1, 2, ..., 8$, where Ie_i is employee intelligence and Is_i is student intelligence. In Fig. 5, the same differences are presented in the form of a polar chart enabling direct visualization of differences.

When analyzing the differences in intelligence in Fig. 9 and Fig. 10, attention should be paid primarily to three sub intelligence important for work in IT positions – Logical-Mathematical intelligence (2), Interpersonal (7) and Intrapersonal (8).

The differences are obvious, they can be considered partly worrying. Fig. 9 shows the clear dominance of Logical-Mathematical intelligence (2) and the Interpersonal intelligence of the employee group over the student group. The difference in Intrapersonal intelligence (8) is small. The authors will provide a detailed commentary in the conclusions at the end of this work.

After obtaining research results from the IT industry, the most interesting experiments were also conducted with students. Knowing the average intelligence values in the IT sector, the two most important, according to the authors, were chosen – Logical-Mathematical and Interpersonal. It was checked how many and which students with their profiles exceeded the average level of intelligence in the IT sector in these two sub intelligences.

This situation is illustrated in Fig. 11. The drawing shows the level of these two intelligences determined by the average values of the IT sector. Then, the profiles of those out of 71 students who had these two sub intelligence higher than those average for IT were shown. 12 such students were found among the first year.

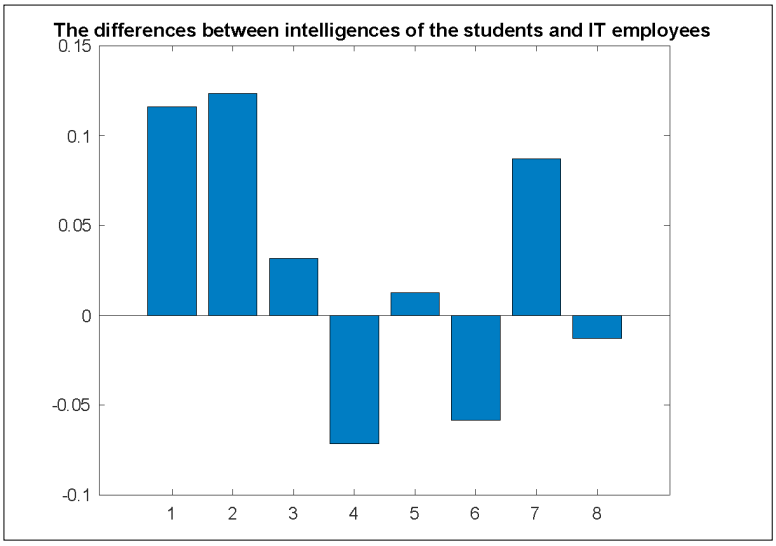

Fig. 9. Differences between sub intelligence of IT employees and first-year students. Positive differences mean that a given sub intelligence is higher in an employee group than in a student group; in order: 1 - Naturalistic; 2-Logical-Mathematical; 3-Linguistic-Verbal; 4-Musical; 5-Visual-Spatial; 6-Bodily-Kinesthetic; 7-Interpersonal; 8-Intrapersonal.

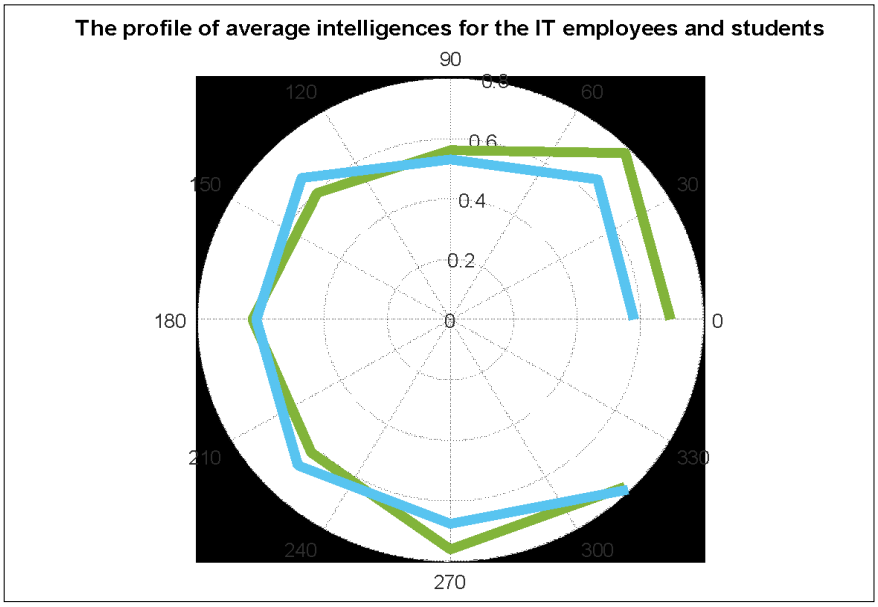

Fig. 10. Employee sub intelligence (green curve) and student (blue curve) expressed using a polar chart. Individual intelligence values can be read on a radius every 45 degrees from 0 every 45 to 315 degrees counterclockwise; in order: at 0 degrees – Naturalistic; 45 degrees – Logical-Mathematical; 90 degrees – Linguistic-Verbal; 135 degrees of Musical; 180 degrees – Visual-Spatial; 215 degrees – Bodily-Kinesthetic; 270 degrees – Interpersonal; 315 degrees – Intrapersonal.

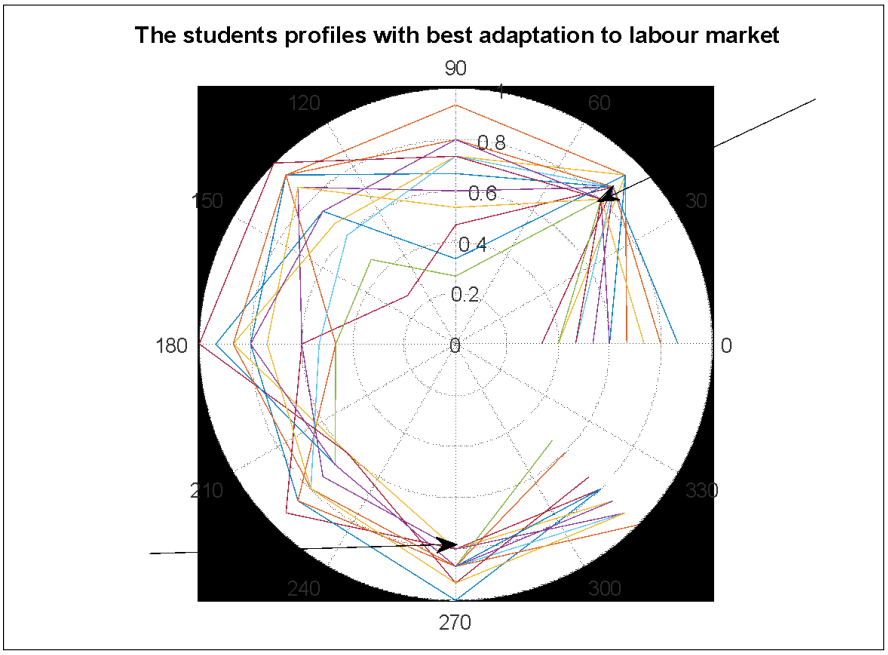

Fig. 11 Profiles of students who show at a given stage of study the best adaptation to the level of intelligence revealed in the employee environment. The arrows in the graph indicate the average level of Logical-Mathematical intelligence (on radius 45) and Interpersonal intelligence (on radius 270) in the IT group.

A similar study was performed for the lowered threshold of these two intelligences in such a way that the average IT level was reduced by the standard deviation. It results, that 32 out of 71 students met the conditions for new, reduced thresholds.

Further studies were devoted to the correlation between partial intelligence. Correlations were calculated (Bruce, P., & Bruce, A. (2017)) according to the formula for the Pearson correlation coefficient between intelligence X_j *i* X_k, j, k ∈ {1, 2, ..., 8}

$$r\,(X_j, X_k) = \frac{\sum_{i=1}^{N} (X_{ji} - m_j)(X_{ki} - M_k)}{\sqrt{\sum_{i=1}^{N} (X_{ji} - m_j)^2} * \sqrt{\sum_{i=1}^{N} (X_{ki} - k)^2}} \qquad (2)$$

where:

i – observation number (of a student);

N – total number of students (here *N* = 71);

X_{ji} – value of *j*-th partial intelligence of *i*-th student;

X_{ki} – value of *k*-th partial intelligence of *i*-th student;

m_j, m_k – arithmetic means in *j*-th and *k*-th column of the observation matrix.

The results of the student and employee tests were examined. To calculate the correlation coefficients, the matlab *corrcoef* function was used, inserting as its parameter the whole observation matrix with 71 rows and 8 columns.

The R correlation matrix is obtained as below. Of course, this is a diagonal symmetrical matrix.

Matrix of correlation coefficients between individual intelligence of Rs students and IT employees – Re:

Rs =

[1.0000	0.0096	0.1695	0.3354	0.3716	0.3728	0.3320	0.2789
0.0096	1.0000	0.4252	0.1944	0.2026	0.1189	0.2332	0.1707
0.1695	0.4252	1.0000	0.4612	0.3565	0.0935	0.2746	0.1817
0.3354	0.1944	0.4612	1.0000	**0.5048**	0.2136	0.4515	-0.0136
0.3716	0.2026	0.3565	0.5048	1.0000	0.0730	0.3804	0.2985
0.3728	0.1189	0.0935	0.2136	0.0730	1.0000	0.3914	0.0621
0.3320	0.2332	0.2746	0.4515	0.3804	0.3914	1.0000	0.1136
0.2789	0.1707	0.1817	-0.0136	0.2985	0.0621	0.1136	1.0000]

Re =

1.0000	0.1674	0.1786	-0.0609	0.1370	-0.0568	0.1459	0.3397
0.1674	1.0000	0.3247	-0.0130	0.1892	-0.0934	-0.0321	**0.5387**
0.1786	0.3247	1.0000	0.2846	0.2714	0.2388	0.1570	0.0994
-0.0609	-0.0130	0.2846	1.0000	0.3429	0.4780	0.1264	0.0817
0.1370	0.1892	0.2714	0.3429	1.0000	0.4581	0.3706	0.0435
-0.0568	-0.0934	0.2388	0.4780	0.4581	1.0000	0.3205	-0.0623
0.1459	-0.0321	0.1570	0.1264	0.3706	0.3205	1.0000	-0.2939
0.3397	0.5387	0.0994	0.0817	0.0435	-0.0623	-0.2939	1.0000

In the first matrix, we find the highest positive correlation between visual and musical intelligence, which is rather a curiosity, a coincidence for this group of students. In the IT employees group we see a relatively high correlation between Logical-Mathematical intelligence and Intrapersonal intelligence. These are two intelligences that interest us very much. This correlation seems to be the result of many years of IT adaptation to the nature of the work. In the employee group, high Logical-Mathematical intelligence is almost a distinguishing feature of the profession and supports or shapes Intrapersonal intelligence. There is no such correlation in the group of students for obvious reasons. In this group, Logical-Mathematical intelligence is clearly lower. This observation will be commented in more detail.

The mentioned correlation between Musical and Visual-Spatial intelligences is the strongest in the student group and amounts to approx. 0.5. Rather, this factor is not surprising – both intelligences are associated with imagination, creativity, thinking of the right hemisphere. The correlation coefficients between Linguistic-Verbal and Logical-Mathematical intelligence are also quite high (0.42). The last can probably be explained by the educational emphasis on these two very important teaching subjects in the last ten years of the student's life. The correlation coefficient between Interpersonal and Musical intelligences is also relatively high (0.45). it can also be explained by group activity of people playing or just enjoying music.

The lowest correlation coefficients are 0.11 between Interpersonal and Interpersonal intelligences. Both of these partial intelligences are important in the profession of IT engineer. While the Intrapersonal intelligence in this group is high (the highest), the Interpersonal intelligence important for future teamwork in many IT companies in the country and in the world is worrying. The surveyed students are only in their first year of study, but it is worth considering their social competences development. The correlations between Logical-Mathematical and Naturalistic intelligences are very low (0.01), which is not surprising, although it should be remembered that the great achievements of artificial intelligence have many roots in nature and medicine.

Research of the second-degree computer science student group

The next student group under consideration was the first year of computer science at second-cycle studies (chronologically – the fourth year of study). The test was completed by 29 students of this group and here the distribution of multiple intelligences was obtained with the means:

$$m_i = [0.5172 \;\; 0.6690 \;\; 0.5586 \;\; 0.6253 \;\; 0.5333 \;\; 0.6069 \;\; 0.6782 \;\; 0.7678];$$

and standard deviation:

$$s_i = [0.2060 \;\; 0.1786 \;\; 0.1731 \;\; 0.2156 \;\; 0.2218 \;\; 0.2148 \;\; 0.1993 \;\; 0.1529];$$

For easier comparison of these results with the results obtained by first-degree students, Fig. 12 presents both histograms side by side. On the right is the IT staff diagram already discussed. The differences are noticeable, although analyzing them requires some concentration. The most important bars in the histograms are the second (Logical-Mathematical intelligence), seventh (Interpersonal intelligence) and eighth (Intrapersonal).

For the presented data two zero hypotheses were made about the lack of difference between the average values of Logical-Mathematical intelligence (second bar) and the lack of difference between the average Intrapersonal intelligence (last – the highest bar on both charts). These hypotheses, tested by means of the Matlab function ttest2 mentioned earlier, were not rejected at the significance level of 5%, which means that we cannot write about differences in intelligence of first- and second-cycle students.

Conclusions

The authors would like to emphasize here their belief in the significance of these and similar research both for the university environment and for cooperation between the university and the IT sector. For universities, this research is important because the student is educated to achieve the appropriate effects: in addition to knowledge and

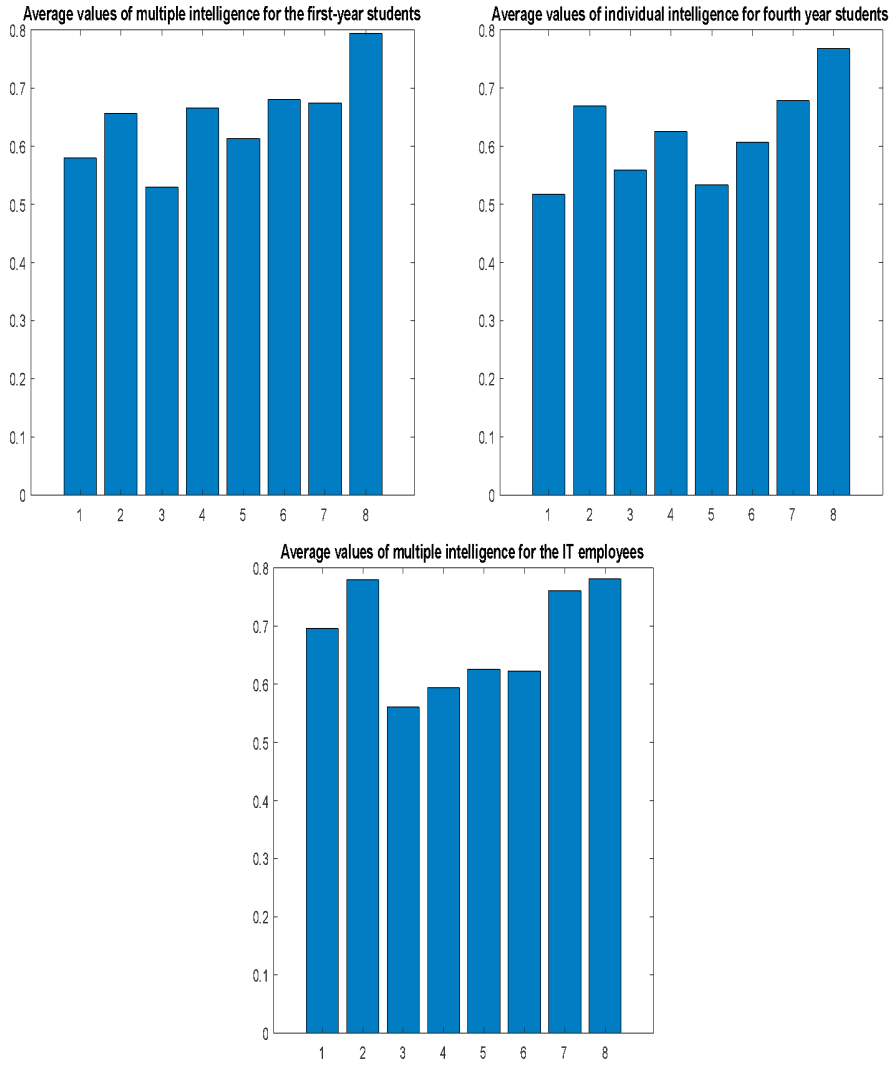

Fig.12. Comparison of partial intelligence distributions for 71 first-year first-cycle computer science students (left), 29 second-cycle computer science students (histogram in the middle) and 36 IT sector employees (right); in order: 1 – Naturalistic; 2 – Logical-Mathematical; 3 – Linguistic-Verbal; 4 – Musical; 5 – Visual-Spatial; 6 – Bodily-Kinesthetic; 7 – Interpersonal; 8 – Intrapersonal.

competence, also appropriate social attitudes. Tests described and carried out by the authors may contribute to clearly making students aware of the importance of these attitudes and how to shape them. Tests can be a chance for the IT sector to identify future employees earlier.

As for the test methodology itself, it was tried to maintain similar conditions in all research groups – preparations, discussions, and application of technologies supporting

the test. First, students were introduced to the theory of prof. Gardner without giving it any special significance, but paying attention to the positive aspects of knowing about your own capabilities, strengths and weaknesses. A student who is aware of the existence of multiple intelligences will find it easier to achieve self-esteem, self-potential and set proper goals (Campbell B., 1996). The use of Gardner's theory in education, which is constantly discussed, is highly valued by many critics by many teachers, but meets the expectations of our (Polish) legislation authority recommending the individualization of the teaching process at every level of education. The authors approached the research with a positive attitude to this theory in the hope of its future use and implementation.

The course of classes resulted in a great interest of students, especially in the perspective of future adaptation to the requirements of the labor market. Surprisingly the relatively low was the indicator of Logical-Mathematical intelligence typical for representatives of studies in the field of engineering and technical sciences. The reservation concerned first-year students and in the IT staff group the indicator was already at the expected level. As for the first-year students, it should be remembered that they are in the process of selection and many of those lowering the average Logical-Mathematical intelligence will simply not finish their studies. This conclusion is based on the many years of experience of the first author who has many responsible functions in academic practice. It allows to notice a statistically justified increase in the average mathematical and logical intelligence in higher years after elimination by the subject of teaching – mathematics, often a significant percentage (e.g. 30–40%) of students in the first year of computer science. The high average Intrapersonal intelligence in the first year of computer science should not come as a surprise. Computer science students are mostly introverts, confident, sure of easy access to any information, focused on their own problems. In addition, the features of such behavior are deepened by belonging to the so-called Generation Y widely and easily using information and communication technologies. It is a generation of children and young people who rather gave up street football and playing in the bosom of nature in favor of smartphones. This led to and shapes the attitudes we observe.

The first author has been conducting research among student groups for didactics for years. He conducted this research in three different universities and in various environmental roles – as the director of the institute, head of the department, and finally for almost 10 years as the dean of a fairly large faculty of computer science (1500–2000 students). These studies were based both on MBTI tests (McCrae and Costa, 1989), but also on the original idea of verifying social competences. In the last test conducted since the beginning of the century, students anonymously rated themselves on the Likert scale (1–5) for activity in the environment, stress resistance before public speaking as well as tolerance, mobility, creativity and other social features. The first two features mentioned – environmental activity and readiness for public appearance without stress are the competencies characteristic of an extroverted person with Interpersonal intelligence. The author's many years of research indicate that these features are rated very low by IT students. Activity understood as involvement in the affairs of the faculty, university, student environment or city or organization outside the university is rated very

low. In 10 selected years, it obtained an average mark of 2.88 (on a scale of 1–5), and resistance to stress before a public appearance achieved even lower marks – on average in the same period 2.43. In case of the last one there are typical mass self-assessments at level 1, i.e. the lowest.

There is a stereotype of computer science professional as a dedicated to programming in isolation. Getting back to the problems of multiple intelligence, the dominance of Intrapersonal intelligence among young IT professionals is justified many times.

Meanwhile, corporate reality is completely different. Interpersonal intelligence is extremely important in the context of work in IT companies, where teamwork is often the basic way to accomplish tasks. It is true that this is often remote work or does not require particularly noisy behavior or extroverted dynamics.

For this reason, the experiment of searching for people with similar intelligence can contribute to creating and deepening relationships between students, stimulating their mutual interests.

The experiment in the first year of study with the search for students "similar" to each other in terms of multiple intelligences was very successful. Perhaps it caused the desirable rapprochement of individual student groups and raising Interpersonal intelligence throughout the year. Teachers noticed at the end of the semester more students talking to each other than those absorbed in smartphone resources, which was typical at the beginning of the semester. Of course, it is difficult to clearly link it with this experiment, but it is worth noting the change going in the right direction.

The experiment with comparing the intelligence of students (two selected sub intelligence – Logical-Mathematical and Interpersonal) with the intelligence of IT staff evoked the greatest emotions. The students awaited the publication of simulation results indicating those who would already meet any corporate criteria at a given moment. Those who, in the scope of these two intelligences, exceeded the average value of these intelligences in the surveyed company were extremely satisfied, they received congratulations from other students. It was certainly desirable social competence.

This experiment did not disclose all the names of students who met the requirements. For example, 10 out of 12 were disclosed so as not to discourage others, to leave hope and positive self-esteem.

An interesting skill acquired as a result of observation of experiments was the ability to immediately assess the profile of intelligence. For example, the room broke into laughter when two profiles were presented (as in Fig. 5) and one of them was very diverse in terms of individual intelligence. For these reasons, the order of intelligence set out at the beginning (moreover, proposed by Gardner) was not changed.

Analyzing the histograms in Fig. 12, it is worth noting that fourth-year students are the "link" between first-year students and the labor market. Although the differences between individual sub intelligence are statistically unjustified, the histogram of fourth-year students already has a better structure, closer to that observed in the IT sector. It can be caused by the fact that some of the students are already hired by the corporation. For example, their desired Logical-Mathematical intelligence is in their third place, not in the fifth place as in the first year. The value of Interpersonal intelligence is also high. So changes are moving in the right direction.

The ability of the IT sector to assess the preferences of students to work in IT companies can be an extremely important future effect of such practical research. This will have to be done with the consent of students and with respect for their privacy, also with the protection of their rights arising from the protection of personal data. This is a great opportunity for HR cells in companies and a chance for closer cooperation in the area of business – academia.

The most interesting closing of the experiment would be to carry it out again in a few years, e.g. in the second degree of studies, and maybe even under employment conditions. For obvious reasons, this is difficult but possible. At this stage of the research, the authors decided to share what they observed, counting on inspiration for similar research in other environments.

The authors thank people who indirectly influenced the creation of this work, in particular teachers of Primary School 22 in Kielce, Beata Cias-Smutek, Grazyna Kaminska, test inspirator Laura Candler and students additionally involved in the organization of tests – Anita Wachala, Karol Hliwa, Paweł Wartel, Patryk Madej. Special thanks go to first-year computer science students Anita Wachala and Karol Hliwa for the organizational contribution and co-authorship of research reports published in a local journal (Wachala A. *et al.*, 2019)

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