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A Method of Selecting Computer Science Students for the IT Market Based on their Predispositions Resulting from Multiple Intelligence

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Abstract. The aim of this study was to determine the predispositions of the studied groups of students to work in the IT sector. The basis for predisposition assessment was their voluntary self-assessment of certain preferences, which are related to the theory of multiple intelligences of Professor Gardner. The study was conducted on a reference group of IT sector employees, assuming that they will be the model, to which the results of the study will be related. The method used to obtain data about the students' predispositions was a test carried out in an auditorium mode or online. More than 500 students from several countries were surveyed and interesting statistical material was obtained allowing for comparison between groups. The most important result was to find a way to sort the students into groups in order from most similar in their aptitude to the market pattern to least. This made it possible to determine the boundary beyond which students could be considered selected for a job in the IT sector. Statistical hypotheses about the similarity of the student groups to the reference group were verified. The results were both positive, confirming that a large percentage of students have predispositions to work in the IT market, and less promising.

The authors are convinced that the method can be applied all over the world, as they examined groups in very diverse countries, taking into account, for example, location, education system, culture or religion.

Keywords: multiple intelligences, engineering education, student's personality, profile of intelligence, work market, affective computation.

1. Introduction

Professor Howard Gardner dealt with multiple intelligences theory as early as in the 1980s. To summarise it in the briefest form, the theory assumes that every human being possesses many equal intelligences (sub-intelligences) of varied strength (intensity), creating a specific, unique profile, changing over time, constituting the development potential, especially for a child. Having conducted numerous studies, incl. (Gardner and Hatch, 1989), Gardner published his thought in a book (Gardner, 1992), and then, twenty years later (Gardner, 2003), assessed their development and impact on the practice of upbringing (Gardner, 2003). Works by Howard Gardner, published also in Polish (Gardner, 2002) caused a great resonance in the world of science, including recognition and criticism (Smith, 2002; Battro, 2010; Battro *et al.*, 2010; Silver *et al.*, 2000; David, 2014; Gardner, 1995). There were proposals to expand the number of considered intelligences from the initial seven through eight, a few years later, to more, suggested by Gardner and including such intelligences as spiritual, emotional, moral, existential, sexual, or digital one (Chen *et al.*, 2009). It is the last intelligence, should its distinctiveness be substantiated by the results of the research that ought to be of interest to the authors and the population of students mentioned in the title herein. Its importance seems to be constantly growing and it seems that this area of research is and will be a challenge for future researchers.

Howard Gardner's theory of multiple intelligences is based on several basic theses formulated by its author: We all apply a full set of (minimum) 8 intelligences – this makes us human and, everyone has a different intelligence profile (everyone's intelligences are developed differently) – even twins have different profiles. A reflection of Howard Gardner's vision may be his metaphor comparing the human brain to a set of computers (Gardner, 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:

1. Naturalistic.
2. Mathematical and logical.
3. Linguistic.
4. Musical.
5. Visual.
6. Kinaesthetic.
7. Interpersonal.
8. Intrapersonal.

The order of the intelligences listed above is not determined; one should remember that they are equal. This order will have organizational significance – in the software used, the intelligences will always appear in the same order, also in the charts.

According to Silver *et al.* 1997, Campbell *et al.* 1996, and Cherry, 2021, Gardner's intelligences can be described in more detail as follows:

Naturalistic intelligence

This type of intelligence is based on getting to know, appreciating, and understanding nature. A person gifted naturalistically "feels" nature, cares for the world, for animals and for plants. Such person has the ability to understand and draw conclusions as well as reap benefits from the environment. Professions characteristic for this type of intelligence include, for example, a cynologist, botanist, veterinarian or farmer. Children with well-developed naturalistic intelligence skilfully classify various objects in hierarchies (they rank things that are more important and less important), they notice patterns functioning in nature. Children – naturalists actively spend their time outdoors, they like excursions, picking mushrooms and collecting leaves.

Mathematical and logical intelligence

This intelligence is commonly present in modern schools and is very important not only in education, but also in adult life. Its importance for the development of societies cannot be overestimated. It is a type of intelligence that is based on cause-and-effect thinking. It manifests itself in perceiving the world through sequences of events and logical thinking. The IQ tests, popular to date, have focused on this type of intelligence. People with this type of intelligence use logic, numbers, diagrams, and easily perceive relationships and connections among pieces of information. Things that do not make logical sense are worthless to them. Such people tend to think abstractly and conceptually, are inquisitive, systematic, and thorough and it is easy for them to think and behave in an ordered, algorithmic manner. They like to ask questions during school classes, they are well organized and use logical arguments. These skills are extremely important for mathematicians, computer scientists, bankers, physicists, chemists, doctors, and engineers.

This type of intelligence is referred to by maths and programming teachers in secondary schools and universities. This intelligence is indispensable in the study of mathematics, computer science and telecommunications and their application in all IT professions and specializations.

In the research herein, this intelligence will be treated as one of the key ones.

Linguistic intelligence

In other words, this is the ability to use words and language freely. People with verbal intelligence choose their words carefully because they can identify subtle differences of meaning among words and they have a sense of the rhythm and sound of words. They have rich vocabulary and are keen to use synonyms. They use words for the purposes of entertainment, information, or persuasion. They like literature, playing with words, they are eager to participate in debates; they skilfully perform written work. To learn another foreign language is easier for them than for others. In consequence of possessing such skills, they do well in such professions as a writer, journalist, columnist, lawyer, teacher, or translator.

Musical intelligence

This type of intelligence appears first. Musical children are keen to sing, hum, play whatever instrument they can, simply surrounding themselves with music and sounds. Musical intelligence is easy to develop by combining music with everyday activities: listening to music while doing housework, singing, humming, rhyming, taking the child to concerts and walks in the park, encouraging public performances and composing. One can enrol one's child for rhythmic or singing classes as well as for a course of playing the instrument. In adulthood, this intelligence is revealed by the love of music, the search for good and favourite music, as well as the ability to play musical instruments. The professions associated with this intelligence seem obvious.

Visual intelligence

This type of intelligence enables one to understand one's vicinity through shapes and images from the outside world and one's imagination.

A person possessing this type of intelligence "thinks in pictures", i.e., uses the imagination. Visually intelligent children pay attention to details, and everything is important to them, and they are highly sensitive to surrounding objects, colours, and patterns. They like doing various types of art work, arranging puzzles, reading maps and they know how to combine colours in a harmonious manner. They are observant and very often use their imagination-visualization; they willingly illustrate matters in the form of diagrams, graphs and tables and they involve all the senses in the process of remembering. A child with a developed spatial intelligence is very inventive and creative.

When possessing developed visual-spatial intelligence, children have rich imagination, prefer books with many pictures, and are great at jigsaws, blocks, and construction toys. In adulthood, this type of intelligence is useful in many professions related to imagination and space. Visually intelligent person can become a road and bridge engineer, graphic designer, architect, filmmaker, but also a poet, naturalist, or a cartographer.

Kinaesthetic intelligence

Children with high kinaesthetic intelligence love dancing and sports. They are happy to carry out various types of work by themselves, e.g., DIY and sculpting. They use body language on a daily basis and make a lot of gestures. Without the use of logical and conscious thinking, they can perform difficult manoeuvres, both with their own body and with objects. They have perfectly developed automatic reactions. They can plan activities; divide tasks and they have great spatial organization. Children with the developed intelligence of this type are fond of kinaesthetic games, preferably in groups. Erroneously, adults call such children "kinaesthetically hyperactive". Such children are very sensitive to touch.

School age children with developed kinaesthetic intelligence often have problems at school because they are expected to be focused and quiet, that is, to simply sit at the desk. They should be given as many breaks as possible. Classes for such children should be varied and interesting, with the use of various types of appliances (e.g., microscopes, projectors, interactive boards). The easiest for them to remember is what was done, more difficult what was only discussed. In adulthood, this type of intelligence is characteristic mainly for athletes who had these advantages identified in childhood. It is also the intelligence of craftsmen practicing movement and sculptors, drivers, and pilots.

Interpersonal intelligence

People with this type of intelligence simply must stay among humans. They learn through interpersonal contacts. They can be excellent listeners and advisers. They have broad interests and often participate in many additional activities. Critical opinions simply motivate them to action even more.

Children with well-developed interpersonal intelligence are assertive, communicative, easily establish and maintain social contacts, can cooperate, have leadership and mediation skills. They are characterized by the ease of learning about and understanding thoughts, feelings, views and the behaviour of other people and they are tolerant. In professional life, interpersonal intelligence dominates among politicians, higher level officials, teachers, tourist guides, lawyers, and priests.

In the experiment analysed herein, it will be the key intelligence, ensuring good communication in the team, good management, and performance of tasks in an IT company.

Intrapersonal intelligence

People with developed intrapersonal intelligence have the so-called "life wisdom", intuition, inner motivation, and a strong will to act. Such people are a bit reserved, prefer to work alone, and happen to be shy.

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

The best way to nurture a child with well-developed intrapersonal intelligence is to create optimal conditions for him or her to determine the scope of their work and the pace of its performance. Such children must be able to experience independent learning and are looking for "their own" place. An adult with such intelligence is often a type of researcher, thinker, philosopher, writer, but also a computer scientist working independently, a mathematician, poet, naturalist, or traveller. The presence of this type of intelligence among programmers who prefer to immerse themselves in their own thoughts in search of innovative algorithmic or programming solutions should not be surprising. In our considerations, we will also consider this intelligence as one of the three most important ones.

One might wonder which of these intelligences is most important for an IT specialist; it depends on the professional, social and organizational context of the corporation. Interpersonal intelligence will be the least useful for a loner programmer, but it may be the most important for teamwork. In turn, the importance of logical-mathematical intelligence may strongly depend on the IT specialty in the profession, whether such person is a developer, tester or a specialist in AI, databases, web technologies, games, designing systems, etc. – the importance of mathematics in solving tasks may be given equal importance as, for example, the creativity of the employee.

The authors use the terms of multiple intelligences, partial intelligences, and sub-intelligences interchangeably to describe the same concept in the paper. As it has been mentioned, there may be more such types of intelligence. Initially, Professor Gardner proposed this number of intelligences. He was criticized for lacking in-depth scientific research allowing for the extraction of these intelligences. Instead, Howard Gardner relied on his own intuition. Moreover, some believe that these intelligences are simply our talents and skills that distinguish us (Smith, 2008; David, 2014). Others believe that Gardner confuses or does not include learning styles in his classification (Terada, 2018). However, many years of practical application of Gardner's criteria justify their motivational strength (Moran *et al.*, 2006). After the research has been conducted, this view is also shared by the authors of this paper.

An important scientific contribution of the authors included in this paper is the development of a method for selecting students in terms of their suitability for starting work in the IT sector. Instead of the typical procedures of verifying knowledge and competences, an approach allowing to maintain a certain discretion as to the real objectives of the entities conducting the research has been used. An important feature of the method is the possibility of significant anticipation of the recruitment process. The aptitude test considered in this study, based on multiple intelligences, gave a sufficient statistical diversity of the respondents' personalities. Statistical differentiation of whole groups and individuals from the group was also achieved.

Selection task can be presented in a different way, commonly applied in many of the corporations. Candidate's skills are assessed by the tests and exams before hiring for an open position. There can be used MBTI tests to measure the suitability of a candidate for a given profile, like Kent's University tests for the software developers. The next common step is a probation period, when the professional and social activities of the candidate are monitored. The assessment activities are performed at the end of the education, just before starting the professional activities.

All above activities do not contain feedback that is provided by the test considered here. This feedback is provided at the early stages of the studies and is important for the candidate to work in the IT. It makes the candidate aware of the significant features, skill-set and competencies in the future work.

The remaining part of the paper is organized as follows: after an introduction, the methodology of the study is discussed, reviewing the tests proposed by different authors. Then, the selected test, the method of collecting responses and the normalization of the results are presented. Research already published by the co-authors of this paper conducted among first-year students of computer science in Koszalin, Poland and among employees of an IT corporation is cited. Research conducted successively among different groups of students in the country and abroad are discussed in the following chapters, divided into subchapters. The essential part of the work will be the chapter devoted to the problem of students' selection in terms of their usefulness on the IT market.

It is important to emphasize that the selection methods are not based on the students' knowledge or competence, but rather on their positive responses to questions about the areas of intelligence defined by Professor Gardner.

We will present examples of calculations for all considered student groups with different levels of desirability in terms of similarity to the reference group. The paper is concluded with a discussion, conclusions, and references.

2. Research Methodology – Selection of the Test and Preliminary Research

Most often, multiple intelligence tests have not been scientifically defined and standardized (McCoog, 2007; Tai, 2014).

There are many Gardner multiple intelligence tests available. They vary in form (computer-based or paper-based tests), in the number of questions, in the way of marking the answers (marking the appropriate question or the evaluation of each question according to a specific scale), and narrowing down the questions for a specific age group. On the Internet, one can find many tests, which in most cases are treated as fun based on the subjective judgments of the participants. It happens, however, that the test is well calibrated, gives a large spread of results and may be significant for inspiring respondent's reflection and building motivation (Visser *et al.* 2006). Some examples of such tests follow.

One of the available tests is paper-based, prepared by Chislett and Chapman, 2006 available online on the Businessballs e-learning website "Multiple Intelligences Test – based on Howard Gardner's MI Model".

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

The author of the test provided two possible ways of answering: by checking the box next to the question that fits the respondent (with the intention of applying this method of filling in the form into his/her speed of providing answers) or by assigning an appropriate weight in the gradation from 1 to 4, where 1 means disagreement with the question and 4 means full approval.

The results are determined by adding the appropriately marked fields in a given column or, in the case of evaluating the answers, by adding up the values assigned to each question in a given column.

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

Another test example can be found at `literacynet.org`. This is a test developed by Terry Armstrong, as an Internet 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 ranges 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 respondent confirms the completed form by clicking the button below. The user then has 5 intelligence scores available. For the 3 intelligences with the highest score, a description of the type of intelligence and activity appropriate for a given intelligence was provided. The summary includes the numerical result for 5 intelligences.

Yet another example is the paper form test developed by Marsha Fralick (https://www.collegesuccess1.com/InstructorManual4thEd/Learning%20Style/MI_quiz.pdf). The questions are grouped into blocks of 8 for each of the 8 examined intelligences. This test differs significantly from those described above because the respondent is aware of what intelligence s/he is evaluating at the time of the answer, while in the other tests the answers are not grouped and the respondent does not know what intelligence the specific question concerns. Moreover, this test has a time frame of 20 minutes to complete. The answers are plotted on a graph of the value function (type of intelligence). The answers are given on a scale from 1 to 5, where 1 means complete disagreement, and 5 means complete agreement with the statement.

Another interesting test for the IT environment is the programming capabilities test published by the Kent University [https://www.kent.ac.uk/ces/tests/computer-test.html]. Test consists of 26 questions expected to be solved for 25 minutes. Test is applied for a candidate in order to make an assessment of the logical-mathematic skills. This feature is measured similarly as in the IQ tests but is limited to measure competencies obtained in a given stage of the programming skills development. It does not indicate a possibility of the strengthening the weakly developed features of the respondent.

If the teacher knows how to approach the obtained results with reserve and caution and how to properly apply them in educational practice, many such tests can be found on the Internet.

For the purposes of this article, the authors used a test developed by Beata Cias-Smutek and Grazyna Kaminska, Polish teachers from Primary School No. 22 in Kielce, as part of the international project "Sharing our treasures for a better future". The project was inspired by the American teacher Laura Candler (lauracandler.com).

The same test, with its results published in 2020, had already been used by Wilinski A., Kupracz L. (2020) in previous studies at Polish universities and has been discussed in detail later in this paper.

Research on the selected test

The first research using the above-mentioned test and maintaining the anonymity of the respondents was carried out among the first-year students of the faculty of Computer Science at the Koszalin University of Technology, Koszalin, Poland, in March 2019.

It is worth mentioning that the research was conducted on a fairly large sample of 71 students. In his initial research, Howard Gardner used the results of even smaller groups of students, e.g. in their work, Gardner, H., and Hatch, T. (1989), mention groups of 20 people.

The research was carried out on the test selected by the authors and described on the website [sp22.kielce.eu/zawartosc/inteligencje-wielorakie]. The test can be accessed by clicking blue link called "Test". It was created with pupils in mind, as a result of international cooperation, as part of a project carried out by a group of teachers from the Primary School in Kielce. Having tried a few other tests, the authors of the paper have selected this test because of its advantages – it required relatively little time and provided a good, differentiated spread of results in individual categories of intelligence. Therefore, it can be well calibrated.

The questionnaire was made available to students in the form of an .xls sheet containing the same questions that were proposed in the source [`sp22.kielce.eu/zawartosc/inteligencje-wielorakie`].

It is a set of 24 questions or statements (whose adequacy is to be assessed by the respondent), which, in an inconspicuous way (superficially, of course) relate to the individual multiple intelligences of Professor Gardner. The questionnaire is intended to be a platform for spontaneous, quick reactions of the respondent, not a place of detailed analysis of what the author of the questionnaire intended to ask the student about. From this point of view, the organizers encouraged students to react in a reasonably short time.

The content of the survey in accordance with [`sp22.kielce.eu/zawartosc/inteligencje-wielorakie`] translated into English has been presented below (Table 1).

Table 1

The questionnaire as the test with 24 questions or statements

Which of the statements below applies to you?	0–5
I like to sing, and I sing well.	0
I love crossword puzzles and other word games.	0
I like spending time on my own.	0
Graphs, maps and graphic tables help me learn things.	0
I learn best when I can discuss new issues.	0
I like art, fine arts, photography and handicrafts.	0
In my free time, I listen to music a lot.	0
I get on well with people of different personality and interests.	0
I often think of my goals and dreams connected with the future.	0
I like learning about Earth and nature.	0
Taking care of pets and other animals brings me pleasure.	0
I like tasks related to physical movement and role play.	0
Written work is usually easy for me.	0
I find it easy to learn new material in mathematics.	0
I play or I would like to play a musical instrument.	0
I am good at such physical activities as sports or dancing.	0
I like numerical games or logic puzzles.	0
I learn best when I can perform practical exercises.	0
I love painting, drawing or designing things using a computer.	0
I often help others on my own initiative.	0
I like staying outside regardless of the weather.	0
I love challenges when a difficult, mathematical problem needs to be solved.	0
Peace and quiet while learning or thinking are important to me.	0
I read for pleasure every day.	0

Students were able to rank the statements from 0 to 5, therefore achieving the score between 0 and 120 points. The following principles of self-assessment were applied:

- 0 – does not apply to me at all
- 1 – definitely not
- 2 – rather not, it is rarely the case
- 3 – sometimes it is true
- 4 – rather yes, often
- 5 – definitely yes

If the student ranked all suggestions at zero, s/he would obtain the final result in the form of a vector of eight zeros for eight of her/his individual intelligences; if s/he answered all questions with the mark of 5, s/he would receive a result in the form of a vector of eight marks of 15 points for each sub-intelligence.

These results were then normalized to the range [0,1] by being divided by the potential maximum value of the sum of the three responses, i.e. by max $(c_j) = 15$:

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

i = 1, 2, …, M – student's order number;
j = 1, 2, … , 8 – order number of the sub-intelligence.

Where max(cj); j = 1, 2, ... , 8 the maximum value to be ranked by the student in the test for+ each of the intelligences resulting from the three responses in the test for that intelligence. Since the maximum number of points per response is 5, the total for each intelligence a respondent can score is 15.

C_{ij} normalized responses were acquired in this way, each of them within the range [0,1], i = 1, 2, …, M (number of students); C_{ij} j = 1, 2 , …, 8 (number of sub-intelligences).

The principles of calculated the results of the test described above were subsequently applied to various groups of students.

Research results of the students of the first year

The first research on multiple intelligences was carried out by the co-authors among first-year students of computer science at the Koszalin University of Technology. It was an interesting experience because students were selected basically only on the basis of their life intentions and dreams, without having major IT achievements/experience. In the research, two basic types of charts were generated on the basis of original Matlab scripts.

The results of the research for each of the tested groups were collected in the form of Cij matrices of M × N, where i = 1, 2, … M are rows containing data of consecutive students/employees from the first to the last one, of the row number for the first-year group M = 71. j = 1, 2, …, N; N = 8 of student's features (sub-intelligences) were placed in each row.

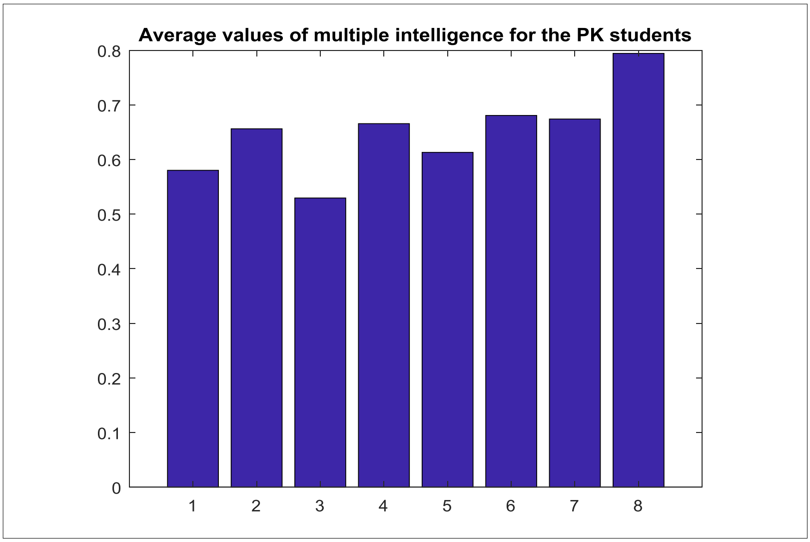

Fig. 1. Average values of partial intelligences for the groups of first year students: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal, consecutively.

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

The results have been presented in Fig. 1 in the form of a histogram.

The obtained m_{pk} vector of average values (The "pk" index stands for this particular university).

$$m_{pk} = 0.5803 \quad 0.6563 \quad 0.5296 \quad 0.6657 \quad 0.6131 \quad 0.6808 \quad 0.6742 \quad 0.7944$$

and the standard deviation from the s_{pk} sample for j = 1, 2, …, 8 was:

$$s_{pk} = 0.2103 \quad 0.2113 \quad 0.1974 \quad 0.2238 \quad 0.2317 \quad 0.1955 \quad 0.1704 \quad 0.1269$$

An overview of the distribution of all students' intelligences for the entire year on a single chart is an interesting result. To visualize this distribution, a Matlab *polar* function was used, which allows to present a multidimensional space in the form of a polar chart, where the distance from the chart centre determines the value of the variable and individual variables (here – partial intelligences) are presented radially at a certain fixed angle of a full circle. In this case – eight variables – partial intelligences, the full 360-degree angle was divided into sectors of 45 degrees, which made it possible to present eight variables (partial intelligences) without superimposing the last variable on the axis initiating the chart.

Next to the two basic charts, the software developed for the publication – Wilinski A., Kupracz L., 2020, made it possible to generate a number of answers extracted from the tangle of data included in Fig. 2.

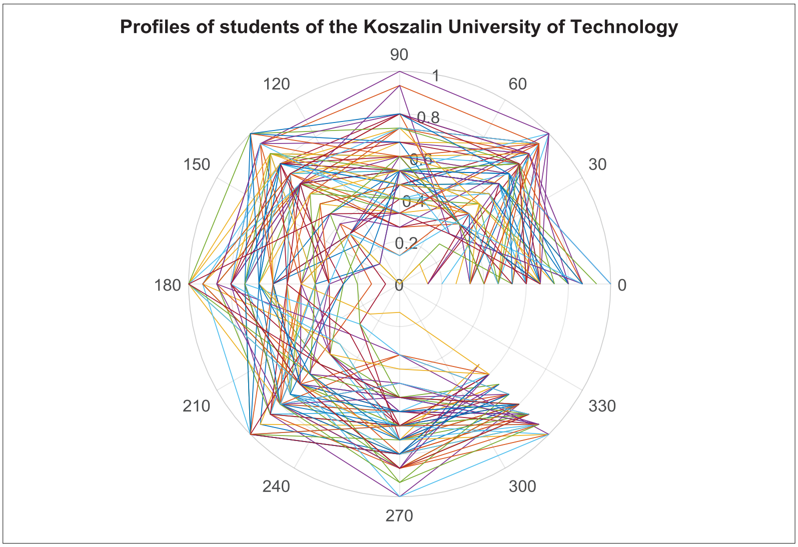

Fig. 2. Polar chart of student profiles of first-year students of Koszalin University of Technology. On the chart, consecutively: at 0 degrees – naturalistic intelligence; 45 degrees – mathematical and logical intelligence; 90 degrees – linguistic; 135 degrees for musical; 180 degrees – visual; 215 degrees – kinaesthetic; 270 degrees – interpersonal; 315 degrees – intrapersonal.

The most important functionalities based on a polar chart such as the one in Fig. 2 include:

1. Calculation of the average values of intelligence for the entire group of respondents (such as shown in Fig. 1).
2. Presentation of the student's profile (individual values of intelligence).
3. Presentation of profiles of any two students for comparison.
4. Presentation of *k* profiles most similar to the profile of the selected student.
5. Comparison of average profiles for different subgroups (e.g. specializations) within the entire student year.
6. Demonstration of student profiles above average and below average for the whole group.
7. Demonstration of the profiles of students with the lowest and highest variance in the value of intelligence.
8. Demonstration of a student (or several students) with the highest average.
9. Demonstration of student profiles that exceed the set values of selected intelligences (it has been used later in this paper).
10. Demonstration of the profiles of the best mathematicians, musicians, naturalists, etc.

There is a huge potential in a discussed method for many studies that can be interesting for both teacher and students. Back to Fig. 2 – there is a specific feature of this plot. It is also present in the next polar plots visualizing results for different groups of students.

Essentially, it is centrally symmetrical, with the obvious exclusion of the gap between 300 and 330 degrees introduced to avoid contact of two variables on one radius.

According to the authors, this feature of the plot allows to conclude that the test has been calibrated correctly, without local densities. Similar features are encountered in the plots for other countries.

In the studies carried out after the test was performed and the data collected in the form of a polar graph, it was possible to verify the interest of students in particular functionalities.

Studying Gardner's works, his efforts to search for people with a rich and diverse personality expressed by large deviations of partial intelligences from the mean intelligence in the group are worth noting. With his PhD student Hatch, Gardner (Gardner and Hatch, 1989) examined, e.g. the indicator of how many times a person crosses the $b_i = m_i + k \cdot s_i$ or $b_i = m_i - k \cdot s_i$, for i = 1, 2,…, 8 barrier, upwards or downwards, where *k* constitutes gain factor of the distance from the mean. Gardner considered the application of multipliers k = 1 and k = 2.

The same was done in the research presented herein. Out of 20 people participating in the study, Gardner found one person that fell within the range of k = +/−1, not exceeding the range close to the mean with any of the intelligences, i.e. not by more than one standard deviation.

In a similar study conducted in a group of IT students, 5 out of 71 people with their partial intelligences in the range m_i +/− s_i, for i = 1, 2, ..., 8, and 17 out of 71 people with their partial intelligences (at least one intelligence) outside the m_i +/− $2s_i$ interval, for i = 1, 2, ..., 8 were found.

The students were very interested in the profile of their own intelligences superimposed on the averages for the whole group. The information whether one is above or below the average for the entire year of students seems motivating and valuable from the perspective of the personality development.

The search for students with profiles most similar to the indicated person, however, provoked the greatest interest. It was an interesting experience since the students, for various reasons, did not know each other very well. Firstly, because the group included the first-year students, they were often participating in classes divided into smaller groups, secondly, this was a new characteristic of the generation of *millennials* immersed in the virtual reality of smartphones, games and applications.

The following principles were applied: any student wishing to maintain anonymity in the auditorium could have the name replaced with a nickname. This assurance of privacy was necessary because it was difficult to predict which names would be shown on the screen as the names of persons having profiles closest to that of the considered student. Then, a student interested in getting to know those "closest" in terms of their intelligence profiles came forward.

Having determined the matrix of "distances" among students and having selected the student (volunteering to be interested in finding classmates with profiles of multiple intelligences most similar to him/her), the classification of students took place. If the interested student was marked with e.g. iD, then the sorting took place in the iD column of D matrix from the smallest d(iD, j) to the largest d(iD, j) for j = 1, 2, ... , N. From the vector established in such manner, k first (nearest) cases were selected, as the name kNN (k Nearest Neighbours) of the selection method suggested, in the increasing order. On the screen, a graph appeared that was part of the polar chart for the whole group of students, additionally with the names of the students (if they had agreed for them to be displayed).

This fragment of the presentation of the research results inspired the greatest interest of students. More than half of the students participating in the classes learned about their “neighbourhood”.

Subsequent studies with the participation of first-year students were carried out after obtaining the results of a test carried out in the selected IT Company.

Research conducted on a group of employees of the IT sector.

The research based on the same test was conducted in one of the representative companies of the IT sector in Koszalin, Poland (the same city that was the study place of the students tested and described above). The authors have been authorised to describe the company as a leading entity in the region, a part of a global corporation, employing diligently selected staff and applying good practices.

The cooperation of the discussed company with the academic community has been going on for many years and has resulted in many initiatives in the form of internship programs, cooperation in creating and updating the scope of IT specializations, building awareness among high school pupils in acquiring attractive and lucrative competences on the labour market without the need for economic migration to the national metropolis. This cooperation is presented in many conferences as an effective industry participation in IT engineering education. It would be difficult to find a better model of the IT environment on the labour market in terms of comparing the intelligence of the staff with that of students. One of the authors of the paper is an employee of this company.

That is the one of the most important studies in this paper, it relates to the challenges of the special issue. Their goal is to search for and build a certain pattern of the multiple intelligences distribution of the IT sector employees in a good and reliable company. There was an assumption taken before the beginning of the work, that the found pattern of the multiple intelligences’ distribution will be a reference pattern for all studies in any of the countries.

The research conducted in this company gave the test results with the histogram of their mean values presented in Fig. 3, as compared with the histogram concerning students’ intelligences.

The detailed distribution of averages and standard deviations for the histogram of the IT staff was as follows:

The average values of partial intelligences in the group of the employees were (The “ie” index stands for these employees of IT sector):

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

and the standard deviation of the sample s_i for i = 1, 2 ..., 8 was:

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

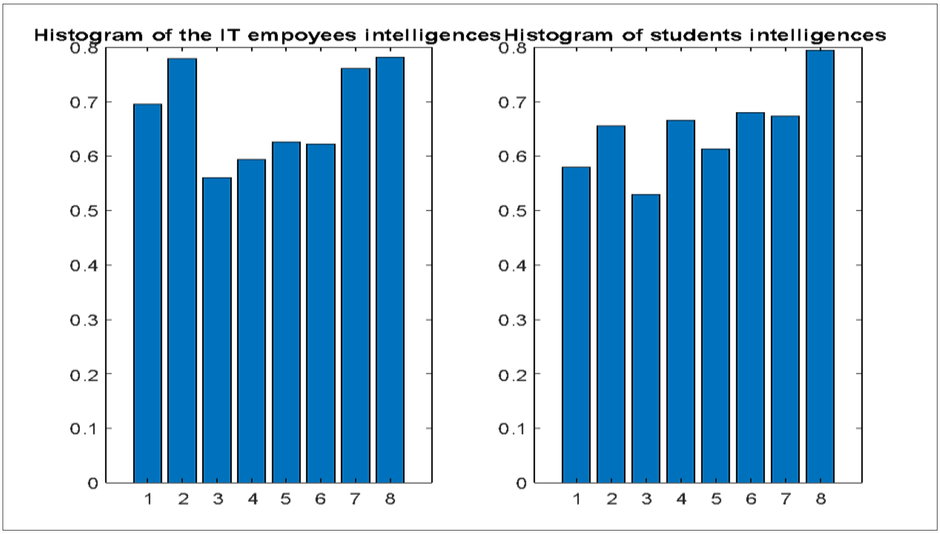

Fig. 3. Histograms of partial intelligences of the IT staff and the students of the IT faculty: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal, consecutively.

A drawing has also been prepared, demonstrating the differences between the distribution of intelligences among the staff and the students – Fig.4.

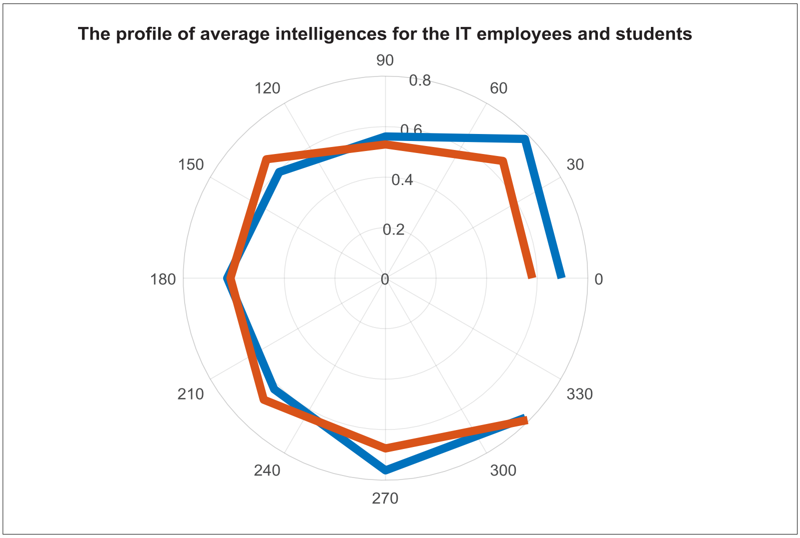

Fig. 4. Sub-intelligences of the staff (blue poly-line) and of the students (brown poly-line) expressed in the polar graph. The values of the particular intelligences may be read at the radii every 45 degrees, anticlockwise from 0 to 315 degrees: 0 – naturalistic, 45 – mathematical and logical, 90 – linguistic, 135 – musical, 180 – visual, 215 – kinaesthetic, 270 – interpersonal, 315 – intrapersonal, consecutively.

When analysing the differences in intelligence in Fig. 4, first, one's attention should be paid to three sub-intelligences important for the work in IT positions – logical-mathematical (2), interpersonal (7) and intrapersonal (8).

The differences are obvious, and they may be considered partly disturbing. Fig. 4 shows a clear dominance of logical-mathematical intelligence (2) and interpersonal intelligence of the staff over the group of students. The difference in intrapersonal intelligence (8) is small.

One can obviously posit a thesis about the similarity between the students' profiles and employees' profiles occurring to a varying degree. There may surely be students that are more or less adapted to an average profile of an employee of a reputable company. Can the level of suitability to work in the IT sector be measurable? The authors have provided an affirmative answer. This could be more precisely defined by the process of selecting students or creating certain rankings, although a great deal of caution should be exercised in providing the students with access to this information, since the phenomenon of demotivation to work and further education might occur.

Maintaining such care, it was decided to test many other groups of students, including those from other countries. Partners (mentioned as authors of this work) from a few countries were involved and research was continued also at other Polish universities.

3. Research Results of other Student Groups

The following groups have been considered consecutively:

- Ukrainian students of the faculty of IT from Kyiv, Ukraine:
  - National technical university of Ukraine "Igor Sikorsky KPI", Kyiv, Ukraine.
  - Taras Shevchenko National University of Kyiv, Ukraine.
- Polish pupils of an IT class in a secondary school from Gdynia, Poland.
- Polish 2nd degree students of the faculty of IT from WSB University, Gdansk, Poland.
- Students of the Koszalin University of Technology, Koszalin, Poland.
- Students of the faculty of IT from Delhi, India.
- Students of the faculty of IT from Bhakkar, Pakistan.
- IT students from Nigeria from the following universities:
  - Chrisland University, Abeokuta, Nigeria.
  - Caleb University, Imota, Nigeria.
  - Edo State University, Okpella, Nigeria.

The research has been performed with the application of the original script activated within the Matlab environment. The results pertinent to particular groups have been discussed consecutively.

3.1. *Research Results Concerning the Students of the Faculty of IT from Ukraine*

The Ukrainian students from Kyiv took part in the study. There were 89 students. Among them 68 students were studying in National technical university of Ukraine "Igor Sikorsky KPI" and 21 students were studying in Taras Shevchenko National University of Kyiv. The students studied different directions of information technologies (IT) – programmers, graphic designers, and network engineers. Their educational programs covered "Information and communication technologies", "Engineering and Programming of Info communications" and "Software engineering". First and second year students aged from 17 to 21 was tested in the poll. The poll was voluntary. The online form was proposed for students, and they could answer the questions at a convenient time.

The test was conducted in auditorium conditions and its voluntary and anonymous nature was assured.

Fig. 5 presents a polar chart of student profiles and a histogram of the average values of individual intelligences. The sub-intelligences compared to the sub-intelligences of the reference group of IT employees have been marked in red {2,7,8}.

Vector S2 of averages values of the intelligences:

S2 = 0.7038 0.6879 0.5977 0.6947 0.6826 0.7530 0.7394 0.7735

The polar graph demonstrates quite even distribution of individual student profiles in the whole area without local condensations or empty spaces. According to the comment stated in Fig. 2, the medial symmetry and the uniform filling of the diagram are present here as well.

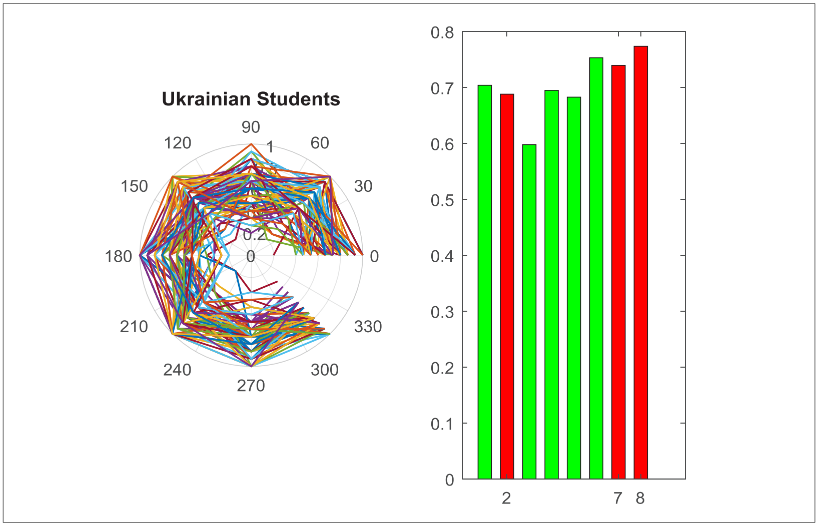

Fig. 5. A polar chart and a histogram of the average values of sub-intelligences in the test of the students from Ukraine. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences significant for the comparison of the universities have been marked in red.

3.2. *Research Results Concerning the Students of the IT Class of a Secondary School in Poland*

Students of the second grade of the 17th Secondary School in Gdynia, studying in mathematics and IT classes, were invited to participate in the research. Participation in the study was voluntary, but the class was selected due to its distinctive profile and the fact that it is a group of 20 students characterized by logical thinking. They achieve high results in exact sciences, take part in mathematics and computer science competitions. Their goal is to pass the matura exam in mathematics and computer science at an advanced level and to continue studying at higher science studies.

The results for this group are presented in. Fig. 6.

Vector S3 of averages values of the intelligences:

S3 = 0.6533 0.7367 0.4800 0.5667 0.6800 0.5867 0.6800 0.7267

This group has a fantastically high level of mathematical and logical intelligence – the closest to that desired by the IT market. Similar research can also be found in Ahvan and Pour, 2014.

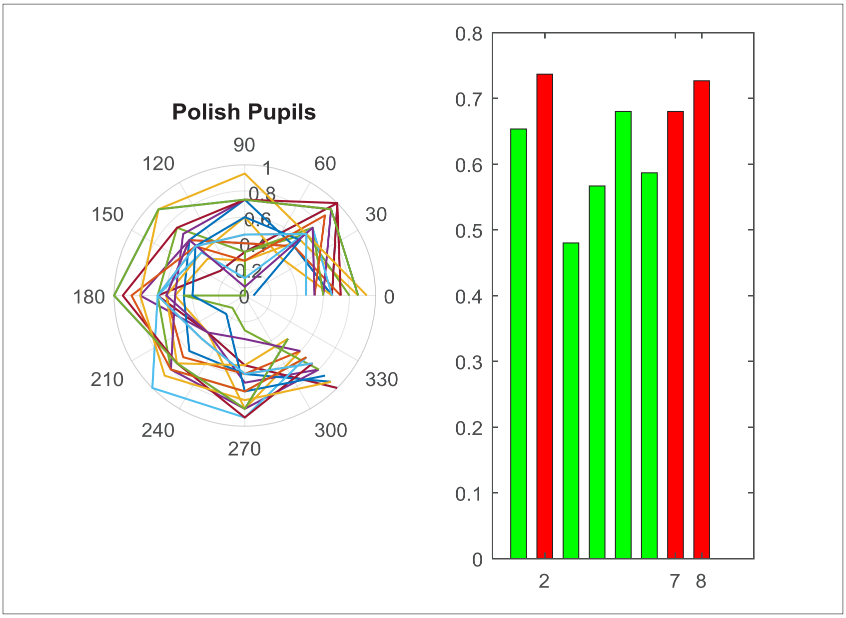

Fig. 6. A polar chart and a histogram of intelligence for Polish pupils of a secondary school in an IT class. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences (2, 7 and 8) significant for the comparison of the universities, have been marked in red.

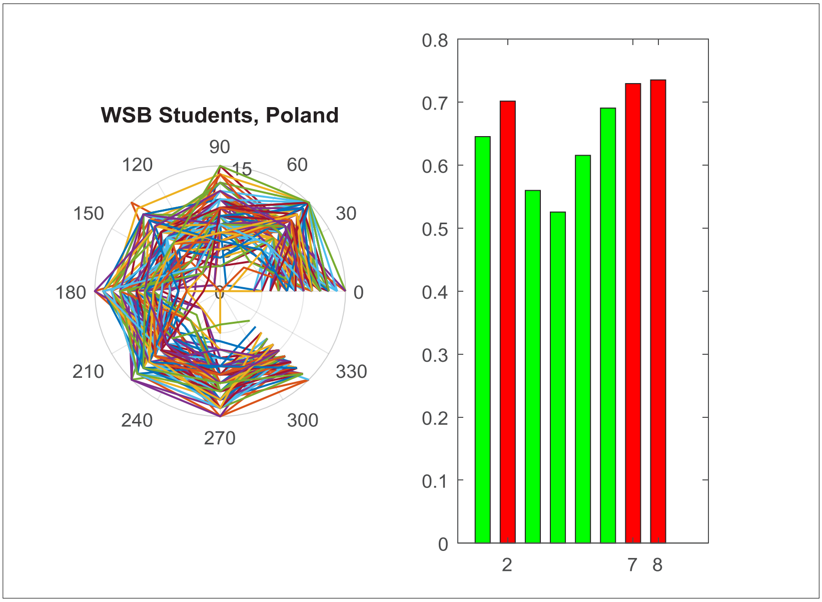

Fig. 7. A polar chart and a histogram of average values of sub-intelligences in the test for WSB students. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences significant for the comparison of the universities have been marked in red.

3.3. *Research Results Concerning the Students of the IT Faculty of WSB University in Gdansk, Poland*

A group of 103 students from WSB participated in the study. They were all computer science students with two different specializations, computer networks, and computer applications. The test was performed as part of a lecture in the class on computational intelligence. Before it started, all students agreed to take part in it.

During the next classes, students could compare their profile with other anonymous profiles, check their position in the ranking of a given intelligence, compare their profiles in specializations, etc.

The results for this group are presented in Fig. 7.

Vector S4 of averages values of the intelligences:

S4 = 0.6453 0.7016 0.5599 0.5256 0.6155 0.6906 0.7294 0.7353

3.4. *Research Results Concerning the Students of the IT Faculty at the Koszalin University of Technology, Poland*

The results for this group are presented in Fig. 8.

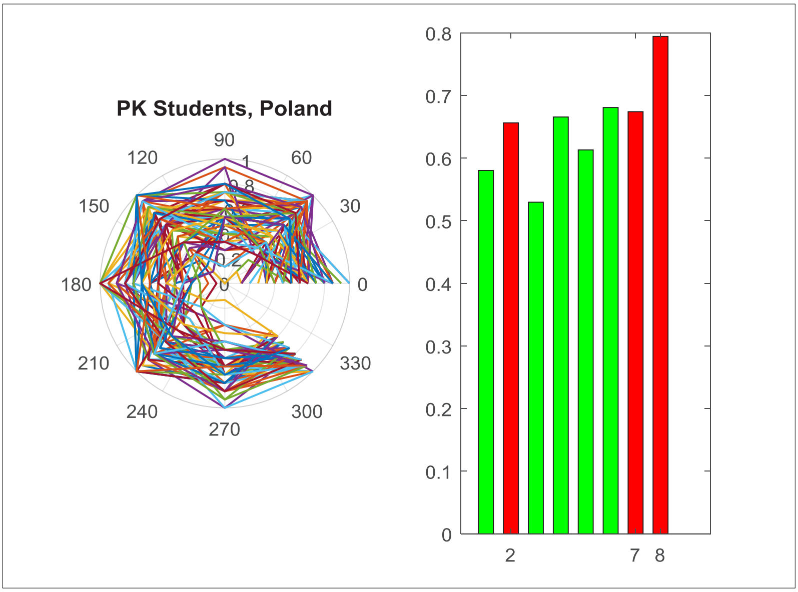

Fig. 8. A polar chart and a histogram of average values of sub-intelligences in the test for the students of the Koszalin University of Technology. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences significant for the comparison of the universities have been marked in red.

Vector S5 of averages values of the intelligences:

S5 = 0.5803 0.6563 0.5296 0.6657 0.6131 0.6808 0.6742 0.7944

3.5. *Research Results Concerning the Students of the IT Faculty from Delhi, India*

A group of 40 Indian students from Netaji Subhash University of Technology (East Campus), Delhi, India is considered for the survey, from which 35 answered the survey. All students are from Electronics and Communication Engineering Stream. They are very much interested in information technology sector jobs and software related work. The reason of their interest is more job opportunities and good salary/package. These students do software courses, different training related to the IT industry. The choice of elective courses taken by the students are mostly computer languages, artificial intelligence and machine learning, data mining and business intelligence, advanced computer architecture, advanced computer networks etc.

The students practice mock tests of IT industries on regular basis. These facts show that these students are mainly preparing for software and IT industries. The test was conducted online.

The results for this group are presented in Fig. 9.

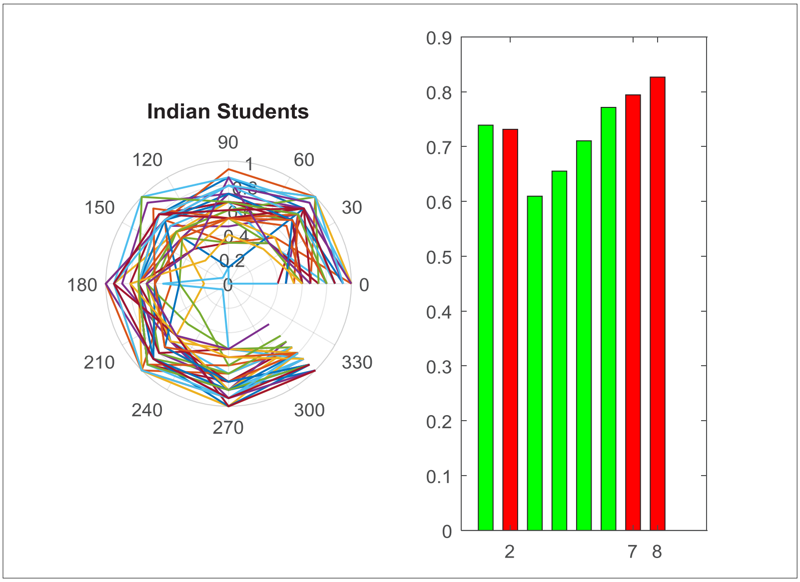

Fig. 9. A polar chart and a histogram of average values of sub-intelligences in the test for the students from India. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences significant for the comparison of the universities have been marked in red.

Vector S6 of averages values of the intelligences:

S6 = 0.7390 0.7314 0.6095 0.6552 0.7105 0.7714 0.7943 0.8267

3.6. *Research Results Concerning the Students from Pakistan*

The researcher co-author personally visited the department of information and communication technology University of Sargodha Sub campus, Bhakkar, Pakistan for the purpose of administration of test. The head of department was approached to seek the permission for data collection from his department. A letter containing the data collection permission was attached with questionnaire. On the date given by head of department the test was performed through paper procedure on 105 BS 8th semester IT students, who were ready to participate in the study. Test was collected from 105 students and data was analysed with the help of programs written in Matlab.

The results for this group are presented in Fig. 10.

Vector S7 of averages values of the intelligences:

S7 = 0.6495 0.4959 0.6476 0.5232 0.6489 0.6330 0.7295 0.7994

The result obtained by Pakistani students differs from the results obtained in other countries. Particularly noteworthy is the low average of the mathematical-logical sub

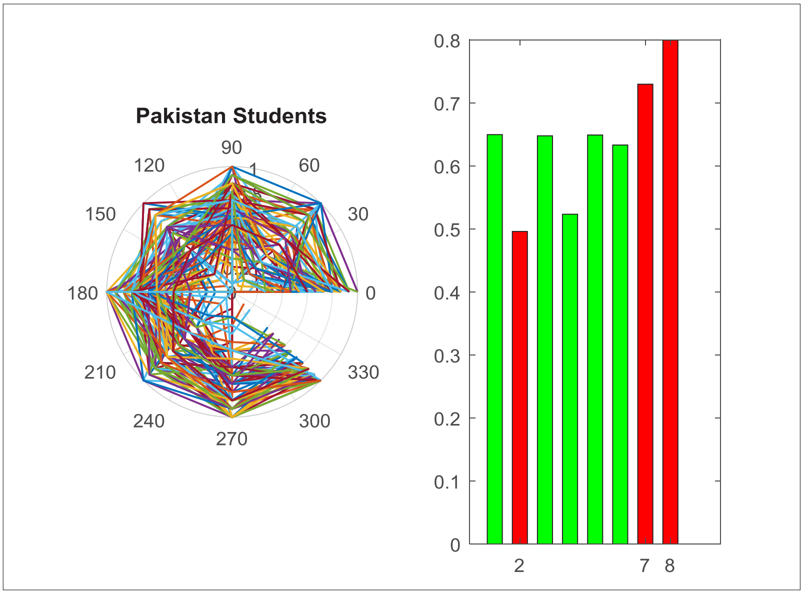

Fig. 10. A polar chart and a histogram of average values of sub-intelligences in the test for the students from Pakistan. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences significant for the comparison of the universities have been marked in red.

intelligence, which is important in this study. However, the last two sub-intelligences studied – interpersonal and intrapersonal – are also important. They are exceptionally high, which predicts well the usefulness on the IT market. It should also be remembered that the test is not based on the students' knowledge and competences, but rather on their emotions, based on a self-assessment of their own attitudes – on the basis of a few questions concerning a certain area of interest. However, the distance to mathematics is quite characteristic. Without further in-depth investigations, it will be difficult to explain. Maybe it is the less active attitude of math teachers, maybe it is the specific climate of the student environment. Most importantly, this group has two excellent scores on two other very important IT intelligences. However, we provide honestly what we have obtained.

3.7. *Research Results Concerning the Students from Nigeria*

Students from three Nigerian universities took part in the test: Chrisland University, Abeokuta, Nigeria; Caleb University, Imota, Nigeria; and Edo State University, Okpella, Nigeria. The test had a total of 135 students who took part. The test was carried out using a Google Form that was sent to the students. Computer science, computer engineering, cybersecurity, and software engineering are among their courses of study. The students range in age from 17 to 30 years old and also between first to final year in the university.

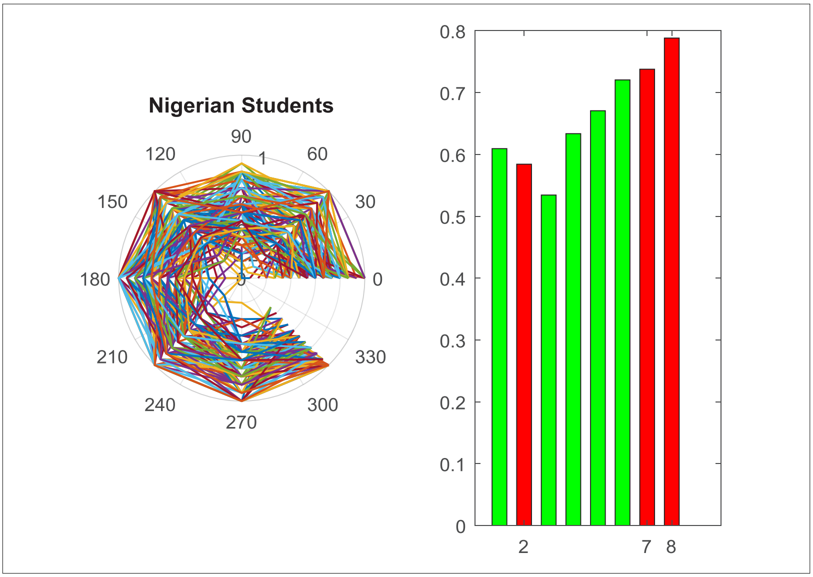

Fig. 11. A polar chart and a histogram of average values of sub-intelligences in the test for the students from Nigeria. Bars in the histogram: 1 – naturalistic, 2 – mathematical and logical, 3 – linguistic, 4 – musical, 5 – visual, 6 – kinaesthetic, 7 – interpersonal, 8 – intrapersonal. The sub-intelligences significant for the comparison of the universities have been marked in red.

Before conducting the test, consent from the students' department heads was sought. Each student was able to fill out the form independently.

The results for this group are presented in Fig. 11.

Vector S8 of averages values of the intelligences:

S8= 0.6094 0.5842 0.5343 0.6336 0.6706 0.7205 0.7378 0.7881

4. The Concept of Selecting Students According to the Criterion of the Partial Intelligences which are Best for the IT Market.

The idea of selecting students (ranking according to the degree of similarity to the desired profile) shall be based on meeting three conditions regarding the values of the three partial intelligences selected by the authors and considered as important and useful for the performance of work in the IT industry. These three selected intelligences are mathematical and logical, interpersonal, and intrapersonal. This choice has been substantiated by the logical relationship of these intelligences with the specificity of working in the IT sector, confirmed by the results of research conducted among employees of a large IT company.

For further considerations, let us adopt the following hypothesis – if, when considering the profile of the i^{th} student composed of j values of his/her intelligence C_{ij}, we find a case that simultaneously meets the conditions:

– The second sub-intelligence (logical and mathematical) of the given ith student C_{i2} will be higher than the average of the second sub-intelligence recorded in the group of IT employees.

And:

– The seventh sub-intelligence (interpersonal) of the given ith student C_{i7} will be higher than the average of the seventh sub-intelligence recorded in the group of IT employees.

And:

– The eighth sub-intelligence (interpersonal) of the given ith student C_{i8} will be higher than the average of the eighth sub-intelligence recorded in the group of IT employees.

Then such student may be positively considered as a prospective employee of the IT sector.

It is not obvious that this barrier for selecting valuable candidates should be the average for IT employees. After all, a large part of the company's employees will be below the average and yet they are employees, probably valuable to the company. So let us treat the conditions described above as preliminary with the possibility of their further modification.

In order to set the conditions of positive selection in such a way, we conducted research on data obtained from individual student groups.

Let's start with IT students from Koszalin.

Let us assume that a company external to the university will be interested in candidates for employment who have desirable traits (intelligence 2,7 and 8 above the average in their company. Of course, such a company at the beginning of such recruitment does not have the distribution of characteristics of its employees, because it did not conduct the test discussed here. Let us make another assumption that such a company will use the pattern of distribution of characteristics (profiles) of the IT company that conducted such a study, and the results of this test are published here. By slightly modifying the software used here, we can generate a polar diagram of students whose profiles satisfy the comparison of student and employee profiles.

Let us determine the mean values of employee intelligences for this purpose:

$$C^m_j = \text{mean}\ (C_{ij}^{IT}) \text{ for } j=\{2,7,8\} \text{ and } i = 1, 2,\ldots, N_{IT} \quad (2)$$

Let us check which student profiles satisfy the condition of simultaneously exceeding the mean values of the selected worker intelligences:

$$C_{ij} > C^m_j \text{ for simultaneously } j = 1 \text{ AND } j = 7 \text{ AND } j = 8 \text{ and for } i = 1, 2 \ldots, N \quad (3)$$

This means that students will be selected whose profiles meet the condition of simultaneously exceeding the average values of the three selected intelligences. By meeting these conditions, they can become elite employees of the company at the very start. It can be predicted that very few students will meet these conditions. Therefore, it will be more practical to have a condition that slightly adjusts the requirements for candidates to work in the company.

Instead of condition (8), let us introduce:

$$Cij > k \cdot Cmj \text{ for simultaneously } j = 1 \text{ AND } j = 7 \text{ AND } j = 8 \text{ and for } i = 1, 2 \ldots, N \quad (4)$$

Where k is the coefficient of reduction of requirements with respect to the average.

It can be, for example, 0.1 of the average, 0.2 of the average, etc. On the labor market, basically all over the world, there is an almost constant demand for computer scientists of all specializations, and therefore looking for employees who are not much worse than those available to the company is the most rational course of action. For the purpose of this paper, we will compare the results of possible recruitment to the reference company using the ratio of requirements reduction in relation to the average values in the company k = 0.5 (that is, according to the half of the average value of the selected three intelligences) of employees in the recruiting company and also for k = 0.8 average value.

Results of the test of selection capabilities

Assuming the reduction of requirements to half of the average value in the IT company k = 0.5, we checked how many employees from the studied IT company would meet this condition for the three selected intelligences. It turns out that almost all employees meet this condition (out of 36 surveyed as many as 35 exceed the threshold of half of the average. For k = 0.8 this condition is met by 20 employees of the company (55%). Employee profiles and profiles determined by the thresholds k = 0.5 and k = 0.8 are shown in Fig. 12.

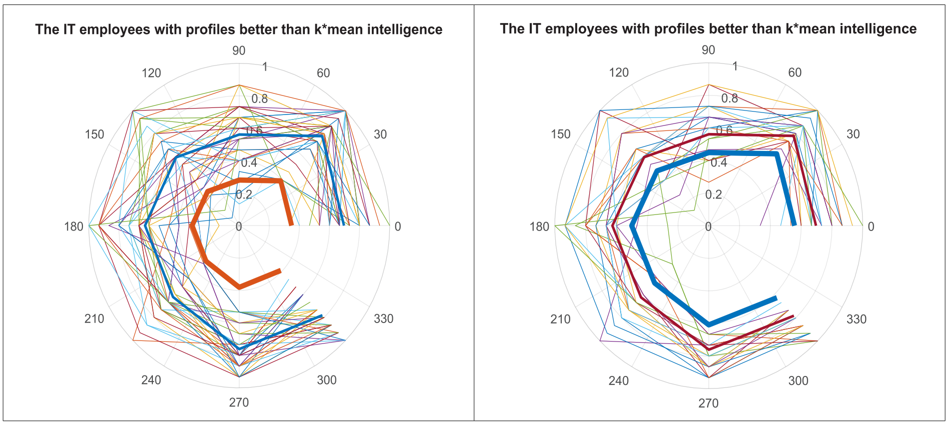

Fig.12. Polar diagram of staff profiles meeting the condition of exceeding the threshold of k=0.5 average for 3 selected intelligences (second, seventh and eighth) – on the left side and for k=0.8 on the right side. On the graph, successively: at 0 degrees – natural intelligence; 45 degrees – mathematical-logical intelligence; 90 degrees – linguistic; 135 degrees – musical; 180 degrees – visual; 215 degrees – kinaesthetic; 270 degrees – interpersonal; 315 degrees – intrapersonal.

The thickest line is the average profile for k = 0.5 (on the left figure) and k = 0.8 (on the right figure). We can observe 35 employee profiles located above the threshold of k = 0.5 for three intelligences in the left figure and 20 profiles above k = 0.8 in the right figure. The other intelligences are irrelevant in the employee evaluation process. The requirements set for the average value at k = 0.5 seem to be too low – too many employees meet them. In further analysis we will consider the threshold k = 0.8 for all student groups.

In this context, let us consider a group of students from Ukraine. The Ukrainian group consisted of 89 students. After setting the threshold of acceptability in recruitment to k = 0.8 average, 39 of them fulfilled this condition, which is illustrated in Fig. 13. The figure shows that for the three selected intelligences all qualified students have profiles above the threshold marked with bold line. Of these 39 students (44%) met the condition.

In the polar diagram of Fig. 13 we can see the profiles of many students meeting the condition of exceeding the contractual requirements for the three selected intelligences at the level of k = 0.8. Each student is one such profile – with the help of data and software it can be unambiguously identified. Thus, we can see the practical, marketing significance of such research for the potential employer, but also for the student. The knowledge of how at a given moment of personal development ranks from the average intelligence in a good IT company can have a great educational value.

In a similar way, the ability to recruit was verified for the other groups of respondents obtaining the results shown below in Table 2.

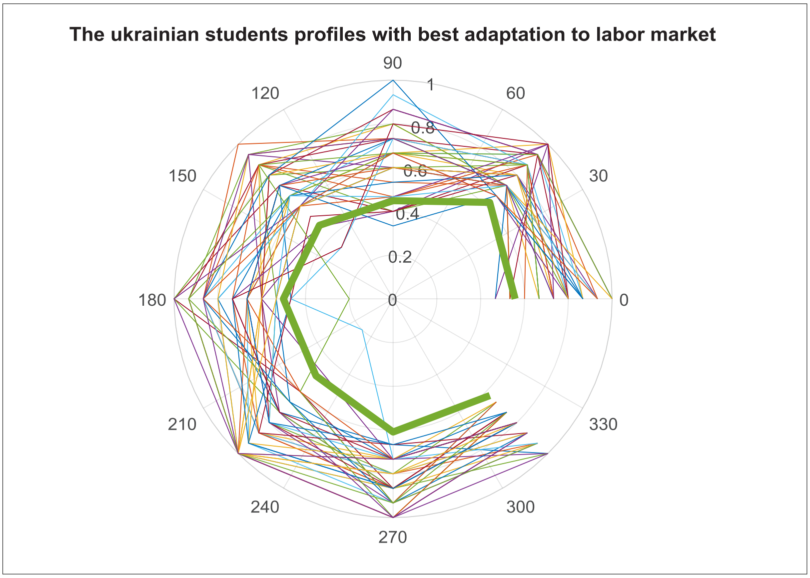

Fig. 13. Profiles of Ukrainian students meeting the condition of exceeding threshold k=0.8 for three selected intelligences. All profiles of qualified students are above threshold k=0.8 marked with bold line. The graph does not include profiles of students who did not meet the condition of exceeding the threshold k=0.8 average.

Table 2

Selection results in different groups of respondents for two values of threshold k

	Emp.IT	Ukr	Pup	WSB	PK	Ind	Pak	Nig
Number of respondents	36	89	20	103	71	35	105	135
Satisfying k = 0.8	20	39	6	43	25	24	30	46
% satisfying k = 0.8	55.5	44.3	30.0	41.7	35.2	**68.7**	**28.5**	34.0
Satisfying k = 0.5	35	80	18	97	62	34	66	105
% satisfying k = 0.5	97.2	90.9	90.0	94.1	87.3	97.4	62.8	77.8

The table shows the selection results for k = 0.8 and k = 0.5 (k is the multiplier of the mean values for the three selected intelligences in the IT staff group). In order to organize and facilitate the interpretation of the results in further proceedings, let us assume the following designations for each group of respondents:

1. This is the group of IT workers in Table 1 labeled “Emp.IT”.
2. The group of Ukrainian students in Table 1 labeled “Ukr”.
3. A group of Polish high school IT students from Gdynia in Table 1 labeled “Pup”.
4. Is a group of students from the Polish University of Technology WSB in Gdansk in Table 1 marked as “WSB”.
5. This is a group of Polish students at the Koszalin University of Technology in Table 1 labeled “PK”.
6. This is the group of Indian students in Table 1 marked as “Ind”.
7. The group of Pakistani students in Table 1 denoted as “Pak”.
8. The group of Nigerian students from 3 universities in Table 1 denoted as “Nig”.

For each of the above groups, the mean values of the sub-intelligences of interest (second seventh and eighth) were calculated to form a matrix Gij, i = 1, 2, …, 8 j = {2,7,8}, whose cell Gij denotes the mean value of the j-th intelligence for the i-th group of respondents. The results are presented in Tale 3.

For the same cases, the standard deviation S_{ij} was considered. The results are presented in Table 4.

Table 3

A table showing the Gij matrix consisting of 8 rows (groups of respondents from different universities) and 3 columns, and whose first represents the mean values of 2nd intelligence (logical-mathematical), followed by the mean values of 7th and 8th intelligence

Emp.IT	0.7796	0.7611	0.7815
Ukr	0.6879	0.7394	0.7735
Pup	0.7367	0.6800	0.7267
WSB	0.7016	0.7294	0.7353
PK	0.6563	0.6742	0.7944
Ind	0.7314	0.7943	0.8267
Pak	0.4959	0.7295	0.7994
Nig	0.5842	0.7378	0.7881

Table 4

The table showing the standard deviation matrix Sij consisting of 8 rows (groups of respondents from different universities) and 3 columns, the first of which represents the standard deviation of the 2nd intelligence (mathematical-logical), followed by the standard deviations of the 7th and 8th intelligence

Emp.IT	0.1911	0.1327	0.1492
Ukr	0.1917	0.1574	0.1460
Pup	0.1829	0.1881	0.1674
WSB	0.2002	0.1550	0.1451
PK	0.2113	0.1704	0.1269
Ind	0.2172	0.1520	0.1234
Pak	0.2076	0.2054	0.2214
Nig	0.2438	0.1703	0.1724

Having these data for eight groups of respondents, an interesting, according to the authors, hypothesis can be made – students of computer science coming from different regions of the world, of different years – do not differ in terms of adaptation to the labor market. Such a hypothesis, in advance may be assessed as very risky, allows one to quantify the relationship between the level of computer science in the student group and the reference employee group. To test the hypothesis that two groups of respondents have mean mathematical and logical intelligence, and then interpersonal and intrapersonal intelligence in pairs statistically indistinguishable Matlab function ttest2 was used. This function allows pairwise comparison of any two groups of respondents of different size under the assumption of independence of both samples. Hypothesis significance test for two means was conducted assuming that the standard deviations in the compared samples are different [Bruce, P., Bruce, A. (2017)].

In our opinion, the most relevant sub intelligence for the considered profession is mathematical-logical intelligence.

Thus, we hypothesize that the mean values of mathematical and logical intelligence of two consecutively selected groups of respondents are equal (null hypothesis). We will perform the similarity verification procedure for all possible pairs of student, employee and pupil groups. The results are presented in the form of a matrix H – Table 5. Each cell Hij of the matrix H, i = 1, 2, ..., 8 and j = 1, 2, ..., 8 denotes the hypothesis that the means of the considered logical-mathematical intelligence for i-th and j-th group are equal (indistinguishable) when Hij = 0 and are statistically different when Hij = 1. The latter case means that the null hypothesis (of equality of means) should be rejected.

The effect of the ttest2 function is the p-value score for each test of the two student groups. This variable can be interpreted as the probability of randomly selecting the values of the mathematical and logical intelligence considered here under the assumption that the null hypothesis is true. The p-value results are presented in matrix P. When rejection of the null hypothesis (for Hij = 1) is justified then the p-values should be very small but have no particular informative value. They confirm the validity of the rejection of the null hypothesis, that is, in our case, the truth of the alternative hypothesis about the difference of student groups. Hypothesis results are presented in Table 4. and p-values in Table 6.

Table 5

Table containing values of H matrix verifying statistical indistinguishability of respondents' groups in terms of logical-mathematical intelligence. Hij = 1 means statistical dissimilarity and Hij = 0 means that the groups are similar (indistinguishable)

	Emp.IT	Ukr	Pup	WSB	PK	Ind	Pak	Nig
Emp.IT	0	1	0	1	1	0	1	1
Ukr	1	0	0	0	0	0	1	1
Pup	0	0	0	0	0	0	1	1
WSB	1	0	0	0	0	0	1	1
PK	1	0	0	0	0	0	1	1
Ind	0	0	0	0	0	0	1	1
Pak	1	1	1	1	1	1	0	0
Nig	1	1	1	1	1	1	0	0

Table 6

P-matrix of p-values for hypothesis results matrix from Table 4

1.000	0.017	0.417	0.044	0.004	0.324	0.000	0.000
0.017	1.000	0.303	0.630	0.326	0.276	0.000	0.001
0.417	0.303	1.000	0.469	0.126	0.928	0.002	0.008
0.044	0.630	0.469	1.000	0.154	0.458	0.000	0.000
0.004	0.326	0.126	0.154	1.000	0.091	0.004	0.036
0.324	0.276	0.928	0.458	0.091	1.000	0.000	0.001
0.000	0.000	0.002	0.000	0.004	0.000	1.000	0.103
0.000	0.002	0.008	0.000	0.036	0.001	0.103	1.000

The H and P matrices summarize tests of statistical relationships between the respondent groups considered.

5. Discussion

When examining multiple student groups and comparing them to a reference standard formed by a group of IT workers, one cannot help but notice the influence of the local environment on the interpretation of the results. In doing so, we make the assumption that the intelligence measurement values obtained in the reference group (IT workers) are reliable and exemplary. Of course, as in many cases of social science research, it is not possible to provide hard logical proof of the validity of a test. We can judge it on the basis of statistical indications mentioned e.g. in the paper by Wilinski and Kupracz (2020). Polar diagrams presented in this paper have regular distributions with approximately equal saturation along each ray representing different sub intelligence (e.g. Fig. 2, Fig. 5, Fig. 7, Fig. 11). This indicates good test calibration and no obvious dominant responses.

By examining only, the statistical distributions of mathematical and logical intelligence in different groups, the hypothesis that groups are indistinguishable according to this trait cannot be confirmed. However, there are differences marked in the hypothesis matrix (Table 4). If we consider the distribution of intelligence in the reference group – here a large entity on the IT market – as a pattern worthy of reproduction in the educational process, then the hypotheses of statistical indistinguishability between this group and the student groups will be of interest mainly. Such hypotheses are represented by zeros in the first row of the matrix H – in Table 4. There are two such cases in this row (we do not count values on the diagonal). These are the zeros in columns 3. and 6. The third in order are Polish high school students and the sixth are Indian students. The latter are not surprising, as they dominate in almost all-important aspects, have comparable to the group of IT workers average value of mathematical and logical intelligence and the highest average values in matrix H of interpersonal and intrapersonal intelligence. The group of students has a high value of mathematical-logical intelligence only, but it is the most important one and that is why it is examined here. However, if we understand that this group is a selected group of young people with mathematical predispositions, such results should not be surprising. This group does not come out so impressively in the tests of adaptation to the labour market, because it does not fulfil the conditions of having simultaneously three high sub-intelligences.

Recall that the hypothesis matrix H (Table 4) is prepared by pairwise testing of all possible groups of respondents, it can be seen that the inner terms of the matrix, except for the first column and the last two, are equal to 0. This means that groups from 2 to 6. do not differ statistically among themselves in terms of mathematical-logical intelligence. These are groups marked with the abbreviations [Ukr Pup WSB PK Ind]. The position of the last two groups of respondents is quite different [Pak Nig], which show no similarity in statistical test with all groups and have ones in matrix – Table 4 (suggesting rejection of null hypothesis of statistical similarity). The two groups, Pakistani and Nigerian instead show similarity with each other and have a hypothesis value of 0 in the reciprocal test.

The results of Pakistani students are different from other countries' respondents. Students who participated in the study learned in the sub-campus of Sargodha University and mostly come from rural areas. However, they have really valuable self-assessments for two other important sub-intelligences, which means that the final assessment of their marketability should not be negative. Co-authors of other countries selected the participants usually from the main University campus maybe that is the reason behind that result of respondents participating from Pakistan not matching with the other participants of the study. And in last, the test was conducted through a paper-pencil test may result in differences in that meaning.

6. Conclusions

The authors of this paper do not prejudge the value of the students of the different countries participating in the experiment. In no case do we dare to generalize the obtained results. The sources of data obtained are quite random and usually result from the research passion of the co-authors who agreed to conduct the test. We should be aware that the same test conducted on a different group of students in a given country, at a different university, in a different year, at a different university, or for the same group of students but at a different time, might yield different results. E.g. when dealing with first year students, it should be remembered that they are in the process of educational selection and many of those possibly lowering their average logical-mathematical intelligence will simply not graduate.

It does not change any particular feature of this test and anticipation of the further assessments during the employment period. It makes aware a young person – full of passion to work in the IT sector – of own weakness and there is still a time to make a change in his career. Revealing this weakness at later stage – at recruitment – results in candidate's rejection, lower performance, worst position or lower salary.

To summarize the study, several conclusions can be mentioned. First, the students were introduced to Professor Gardner's theory without attaching any special significance to it, but they did draw attention to the positive aspects of knowing one's own abilities, strengths, and weaknesses. A student who is aware of the existence of multiple intelligences will find it easier to achieve self-esteem, his own potential and to set appropriate goals (Campbell, 1996). The use of Gardner's theory in education, still discussed, highly valued by many teachers, and criticized by others, nevertheless meets the expectations of e.g., Polish legislator recommending individualization of the teaching process at each level of education. The authors approached the research with a positive attitude towards this theory in the hope of its future use and implementation.

From the course of the study, it was evident that students were very interested, especially in the perspective of future adaptation to labour market requirements. A surprise was the relatively low rate of mathematical and logical intelligence, typical for representatives of studies in engineering and technical sciences. This is rather not the case for the most engaged Indian students and Polish high school students with IT profile.

The high average intrapersonal intelligence in the first year of studying computer science should rather not come as a surprise. Computer science students are mostly introverts, self-confident, confident of easy access to any information, focused on their own problems. In addition, the characteristics of such behaviour are exacerbated by belonging to the so-called generation Y commonly and easily using information and communication technologies.

These assessments are fostered by the stereotype of a computer scientist as a profession dedicated to programming in isolation. Returning to the issue of multiple intelligences, the dominance of intrapersonal intelligence among young IT professionals is justified many times over.

Meanwhile, the corporate reality is completely different. Interpersonal intelligence is extremely important in the context of working in IT companies, where teamwork is often the primary way to accomplish tasks. Admittedly, this can often be remote work or work that does not require particularly boisterous behaviour or extroverted dynamics.

For this reason, the experiment of finding people with similar intelligences can help create and deepen relationships between students, stimulating their shared interests.

Taking these aspects into account, it can be concluded that the thesis put forward by the authors of this paper about the existence of a certain model of intelligence distribution seems justified and indirectly confirmed by the results from many different environments of the world's countries. This thesis appeared earlier in the quoted here work of Wilinski A., Kupracz L. (2020).

While constructing this thesis, it was assumed that the IT company examined in terms of the distribution of multiple intelligences among its employees is representative of the group of good, or perhaps very good global companies. The thesis about the model intelligence distribution presented in this paper is seen as a promising criterion for selecting participants in engineering competencies development programs or internship programs. Going further, there can be created model intelligence distributions for each of IT project roles (e.g. project managers, test engineers, architects, requirements analysts) and applied classification algorithms as a form of career development guidance. The application of this approach is interesting in profiled classes of high schools and first-year IT students, who in the next year of study are faced with the choice of specialization influencing the further development of their careers.

Secondly, it was assumed that the distribution of the intelligence of employees observed in this company would be a model worth recreating, and earlier, research in academic environment at IT faculties.

In the research carried out here, none of the teachers – co-authors operating in various and diverse countries of the world has questioned the validity of the thesis about the correctness of this pattern. The desired pattern in research in various student groups was the desired set of three intelligences – mathematical and logical, intrapersonal and interpersonal. The only difference in these studies was the results of a group of Pakistani students with a low value of mathematical and logical intelligence. These results were commented just below the report of this study. The remaining groups confirmed the correctness of this pattern.

The conducted research was accompanied by extensive correspondence between co-authors from different cultures and environments. It has repeatedly confirmed the correctness and adequacy of the formulated model, also on the basis of direct observation of students and later graduates in local labor markets. According to the authors, an interesting continuation of the research could be the search for correlation between the selection tests considered here based on self-assessment and the results of tests of their programming skills or other skills necessary for a given job, e.g. with the use of Kent University tests.

The most interesting closure to the experiment would be to repeat it in a few years, e.g., in a second-degree program or perhaps even in an employment setting. For obvious reasons this is difficult, though possible. However, at this stage of the research the authors decided to share what they observed hoping to inspire similar research in other environments.

The most important conclusions resulting from this work will be the observation that there are in the university environment, and perhaps even earlier, groups of young people who are well and very well prepared for the labour market. On the other hand, in each environment, in each country, we can find students who stand out in the process of acquiring knowledge and competencies and it is possible to find them using, for example, the selection method proposed here.

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1. The authors would like to thank the people who indirectly inspired this work, in particular the teachers of Primary School No. 22 in Kielce, Poland, Beata Cias-Smutek, Grazyna Kaminska, and the test inspirer Laura Candler from the USA.
2. Authors declare no conflict interests.
3. There is a sentence right next to the questionnaire on page 8 that may help identify the authors. No one on the questionnaire is a co-author of this paper; however, we are moving this section of the article to the TitlePage:

   The content of the survey in accordance with [`sp22.kielce.eu/zawartosc/inteligencje-wielorakie`] translated into English has been presented below.
4. Form page 7 we removed the following text:

   The same test, with its results published in 2020, had already been used by [Wilinski A, Kupracz L., 2020] in previous studies at Polish universities and has been discussed in detail later in this paper.

   For the purposes of this article, the authors used a test developed by Beata Cias-Smutek and Grazyna Kaminska, Polish teachers from Primary School No. 22 in Kielce, as part of the international project “Sharing our treasures for a better future”. The project was inspired by the American teacher Laura Candler (lauracandler.com).

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