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INNOMATH

Innovative enriching education processes for Mathematically Gifted Students in Europe

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Electronic Guidebook of Methods and Tools for teacher facilitators

PART A

Definitions and Characteristics

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Introduction

The main task of PART A is to gather good practices related to the education, development and stimulation of mathematically talented students, as well as to collect the definition of a mathematically talented student. To this end, a structure was designed to facilitate the presentation of the above practices and definitions. In this chapter, we've gathered definitions describing talented/above average mathematically endowed students. They are to help mathematics teachers working with students aged 10-18 to recognize students who are particularly talented in mathematics among their students. The chapter is divided into a theoretical part in which we collect the definition and two parts in which we approach the matter in an operational manner. We collect a set of traits and behaviours that a student should be characterized so that we can qualify him as a talented student. In the last part, we present a few methods that a teacher can use in his work to assess which of his/her students manifests mentioned traits and behaviours.

Definitions/characteristics of giftedness

Set of definitions for gifted/talented school students

- **Gifted / talented student** - the student with an above average intellectual capacity (at the psychometric level, over 130), observing cognitive differences both at the quantitative and qualitative level, a higher maturity (perception and visual memory), capacity development metacognitive at an early age (about 6 years) and intuition in solving problems
- **Gifted / talented student** - the student with an intellectual curiosity, an extraordinary capacity for observation
- **Gifted / talented student** - the student who has an exceptional spontaneity in the school and demonstrates a high ability in academic work
- **Gifted / talented student** - students with creative thinking skills, students with original and divergent ideas, who demonstrate their skills in developing original ideas, being able to distinguish a given situation from several different forms
- **Gifted / talented student** - the student with visual and performing arts skills: this category includes those who have superior skills for painting, sculpture, drawing, dance, vocal and instrumental music and theatre
- **Gifted / talented students** - An intellectual, artistic, or leadership student who can achieve in academic fields and who needs differentiated and challenging activities in order to accomplish and reach his full potential both academically and personally.
- **Gifted / talented students** - An individual who demonstrates outstanding levels of aptitude (defined as an exceptionality to reason and learn) or competence (documented performance or achievement and in the top 10%) in one or more subjects

- **Gifted / talented students** - One-dimensional definitions of giftedness are not helpful. Children are neither gifted by external influences nor are they gifted per se. From a dialectical perspective development is always both an actual component and an objective one. In other words: one is already mature as a toddler, but at the same time the child always needs the “friendly guidance of adults”, in order to achieve that critical-constructive socialisation which allows people to become responsible citizens. Therefore, we do not see talent as a manifestation of performance per se, but as a disposition for high and excellent performance. Kindergarten, school, and the leisure sector provide many opportunities to take up these individual dispositions and, in the best case, transform them into performance. Gifts are specific. The construct of multiple intelligences represents one of several modern models of giftedness and should form the basis of our support. The approach is based on the assumption that intelligence is composed by many individual abilities, which in course of a development and learning process are combined to form higher-level abilities. This means that adolescents are not equally capable of high performance in all areas of intelligence, their talents can become manifest in a domain-specific way. The support of giftedness must therefore be multi-perspective and take place in different spheres of life.
- **Gifted / talented students** are children who are said to be thanks outstanding abilities are able to demonstrate advanced achievements. These are children with achievements and / or potential abilities in one or more areas, such as: general mental abilities, specific skills in the main school subjects, leadership skills, fine arts and performance, psychomotor skills.
- **Gifted / talented students** are children who demonstrate opportunities for advanced achievement in the field of: mental, creative, artistic, leadership skills or in specific subjects and who, in order to fully develop these opportunities, require services or activities not provided by a standard school
- **Gifted / talented students** are characterized by accelerated psychomotor development, cognitive hunger manifested in the form of versatile interests, learning about new phenomena and situations, finding new tasks, as well as frequently asking

himself various philosophical and existential questions, which are often problematic for parents and teachers. Large possibilities in the field of memorizing, storing and reproducing information allow a student capable of acquiring and accumulating more and more knowledge about the surrounding world, which pushes the able child towards increased intellectual activity in the form of the ability to conceptualize, abstract and synthesize and perceive the causal relationship. -effective.

- **Gifted / talented students** are one who have the ability to achieve outstanding achievements in a given field, who displays a high level of general abilities (intelligence) or have some special ability in the sphere of mental activity, for example in mathematics. A gifted student is also a student with a high or outstanding IQ.
- **A gifted / talented student**, in socially understood, it is usually a student who has exemplary behaviour and the highest grades in school subjects. In the psychological sense, a gifted student is one who has a high IQ, high achievements, feels cognitive anxiety, is able to break away from the usual patterns, is able to find himself in a new situation, has ideas for new solutions to old problems, is not afraid of new things.

Characteristics-Executive Functions of gifted students

Some features that can give important suggestions for discovering talented individuals in mathematics are the following:

1. An unusually vivid attention and intense curiosity about mathematics.
2. An unusual speed in learning, understanding and applying mathematical ideas.
3. A great ability to think and work abstractly and the ability to see patterns and relationships in a mathematical way.
4. An unusual ability to think and work with mathematical problems in more ways soon flexible, creative, rather than stereotypical.
5. An unusual ability to move from learning to new, unpredicted situations.

They differ from the general group of students and by the following abilities:

- spontaneous configuration of problems;
- flexibility in handling information; mental speed of fluency of ideas;
- ability to organize information; originality of interpretation; the ability to transfer ideas;
- the ability to generalize;

Talented students in mathematics can have high levels of abstraction and have strong skills critical thinking. They are likely to quickly understand mathematical ideas and choose a creative approach to solve problems.

A gifted student might be one who:

- Ignores schoolwork but spends huge amounts of time pursuing his own topics of;
- Interest to a very advanced level;
- Learns new ideas or skills more rapidly than others;
- Can control their attention better than others;

- Commits entirely to a task that captures their imagination;
- Actively wants to develop that area in which they are gifted;
- Can immediately see multiple angles of perception of the same topic, object or idea;

Renzulli¹ defined gifted behaviours² as those which result from the interaction between above average ability, task commitment, and creativity individuals who can manifest and apply this complex of traits to any potentially valuable area of human performance would be categorized as gifted.

Frasier and Passow's³ 4common traits of giftedness (1994)⁵

- Motivation;
- Communication skills;
- Well-developed memory;
- Insight;
- Imagination/creativity;
- Advanced ability to deal with symbol systems;
- Advanced interests;
- Problem-solving ability;
- Inquiry;
- Reasoning;
- Sense of humour.

¹ Joseph S. Renzuli – Director The National Research Center on the Gifted and Talented, University of Connecticut Storrs, Connecticut (USA).

² Renzulli, J. S., *What is this thing called giftedness, and how do we develop it? A twenty-five year perspective*, *Journal for the Education of the Gifted*. 23(1), 1999, 3-54.

³ Mary M. Frasier (1938–2005) - was a famous African American educator who specialized in the area of gifted education at the University of Georgia.

⁴ A. Harry Passow (1920-1996) – Jacob H. Schiff Professor of Education, he was a one of the world's leading experts on both urban education and gifted education (Teachers College, Columbia University).

⁵ Frasier M. M., Passow A. H., *Toward a new paradigm for identifying talent potential*, Research Monograph 94112, Storrs, CT: The National Research Center on the Gifted and Talented , University of Connecticut.

US Department of Education stresses:

- Performing or showing the potential to perform at a remarkably high level of accomplishment compared with others of their age, experience or background;
- High performance capability in intellectual/creative/artistic areas;
- Exceptional leadership abilities;
- Excellence in particular fields of interest.

Children capable of high performance include those with demonstrated achievement and/or potential ability in any of the following areas:

- General intellectual ability;
- Specific academic ability;
- Creative or productive thinking;
- Leadership ability;
- Visual and performing arts;
- Psychomotoric ability.

Five categories of definitions of gifts and talents are outlined:

- After-the-fact definitions emphasise prominence and outstanding achievement;
- IQ definitions set a point on the IQ scale and persons scoring above that point are classified as gifted (usually two standard deviations above the mean is the cutting point);
- Percentage definitions set a fixed proportion of the school (or district) as „gifted“, based on ability scores or grades;
- Talent definitions focus on students that are outstanding in art, music, sciences, or other specific aesthetic or academic areas;
- Creative definitions stress the significance of superior creative abilities.

Sternberg⁶ describes⁷ an implicit theory that summarises “what we mean by giftedness people’s conception of giftedness”. Five necessary and sufficient conditions that gifted persons have in common:

- Excellence – a gifted person should be extremely good in something;
- Rarity – he/she must possess a high level of an attribute that is uncommon relative to peers;
- Productivity – the superior trait must (potentially) lead to productivity;
- Demonstrability – the trait must be demonstrable;
- Value – the superior performance must be in an area that is valued by society.

⁶ Robert J. Sternberg - an American [psychologist](#) and [psychometrician](#), Professor of Human Development at [Cornell University](#).

⁷ Sternberg R. J., *The Concept of 'Giftedness': A Pentagonal Implicit Theory*. The Origins and Development of High Ability, CIBA Foundation Symposium 178, John Wiley & Sons, 1993, 5-16.

Tools for Identification of gifted/talented school students

- A. Teachers and parents are the best people to identify gifted and talented students. Cognitive and affective characteristics of gifted and talented students which may differ from their classmates. Just as it is important to identify students with learning disabilities and assess their particular learning needs on the learning continuum, it is also necessary to identify each gifted child's specific learning needs and current level of achievement.
- B. There are **Academic Potential Tests like the Raven's Progressive Matrices assessment** which does not need professional administration and which is said to be able to identify underachievers with high potential. A Raven's Progressive Matrices Test is a test designed to measure your non-verbal, abstract and cognitive functioning. In the test, a candidate is presented with a matrix of 3x3 geometric designs, with one piece missing. The candidates' job is to choose the right diagram, from a set of eight answers, that completes a pattern in the matrix that you have to figure out. The questions and answers are all completely non-verbal.
- C. **The Raven's Progressive Matrices Test** was developed in the 1930's by J.C. Raven to research how genetic aspects and environmental aspects influence intelligence. The Raven's Progressive Matrices Test is designed to have no cultural or ethnic bias, so it should measure only the genetic component of intelligence without the influence of environment. The relevant pdf file with more details is "Raven Progressive Matrices Test".
- D. There are also **internal school tests**, which are usually used as a kind of first step **to identify** those students that are quite easily identifiable. In practice, these tools work best when part of an identification matrix that takes into account a range of informal identification tools. For an idea of what this matrix might look like, here is the one test advised by Joseph Renzulli, one of the leading names in Gifted education in the US. Renzulli's method, presents the three-ring conception of giftedness. A detailed process is presented illustrating how students can be effectively screened and identified as gifted and talented

through the three-ring conception approach. The relevant pdf file with more details is “Renzulli Test (Gifted and Talented)”.

- E. There are two formulated tests, run by Johns Hopkins called the School and College Ability Test (SCAT) and the Spatial Test Battery (STB). These tests measure verbal, quantitative, and spatial reasoning ability. These are what are called Out of Level tests which have no ceiling effect as they expose students to questions far beyond their level so they eventually hit a level they can't fulfil or exceed. As far as SCAT is concerned, the Mathematics section measures a student's understanding of fundamental number operations. The STB consists of four sections: Visual Memory Learning, Surface Development, Block Rotations and Visual Memory Recall. The relevant pdf file with more details is “SCAT & STB”.
- F. Wechsler Intelligence Scale for Children (WISC), developed by David Wechsler, is an individually administered intelligence test for children between the ages of 6 and 16. It can be completed without reading or writing. The WISC takes 65–80 minutes to administer and generates an IQ score, which represents a child's general cognitive ability. This test assists teachers or specialists to discover learning strengths and vulnerabilities in each student; therefore, it allows them to offer targeted, individual intervention that is best suited for each student.
- G. The Intelligence Quotient (IQ) is a parameter for assessing general intelligence or evaluating specific factors of intelligence. This is done by a test. So, the IQ can only refer to it, because there is no scientifically recognized and unambiguous definition of intelligence. The IQ determined by the test is compared to a reference group. Such a group can be age-specific (e.g. children and adolescents) or specific to educational levels (e.g. high school). The IQ scale is based on the assumption of a normal distribution with a mean of 100 and a standard deviation of 15. Accordingly, about 68 % of the people in this reference group have an IQ in the middle range between 85 and 115. People with an intelligence quotient of at least 130 are described as gifted, because according to the normal distribution they comprise only about 2.3 % of the

reference group. You can find further information and some IQ tests in the related pdf with the name "Intelligence Quotient".

H. The tool for identification of gifted/talented school students developed by Humboldt University in cooperation with the "Berliner Netzwerk mathematisch-naturwissenschaftlich profilierter Schulen" is a method method for identification of giftedness comprising three parts. The points accumulated in the three parts are added and the school students performing best are accepted into the "Network".

1. Mathematical test (provides 50% of the whole identification test): School students take a mathematical test (75 minutes) with problems which are similar to the ones provided in the Kangourou Competition. For this test a school student can achieve at most 10 points.
 2. Grades from school (provide 25% of the whole identification test): The grades (1 very good, 2 good, 3 satisfactory, 4 sufficient, 5 unsatisfactory, 6 not sufficient) from the last report of the school are added and translated into points in the following way: Mathematics grade multiplied by 3 + German language grade multiplied by 2 + foreign language grade + natural sciences grade (this sum has to be at most 15).
 3. Special skills (provide 25% of the whole identification test): Each of the skills below, which is rated as particularly strong, yields a point. When all of the skills below are rated higher than average, a further point is awarded.
 - a. recognizes basic principles or rules and applies them appropriately
 - b. works in a structured, independent manner and links knowledge elements
 - c. plans and organizes work steps purposefully and quickly is full of ideas, open to new things and interested in many different areas
- I. The tool for identifying gifted students is the questionnaire, the basic tool used to collect data. Its elaboration has a multidisciplinary character, in the sense that it requires knowledge from several scientific disciplines: economics, statistics, mathematics, sociology, psychology, etc.

The questionnaire must be designed so that the reading of the questions, the observance of the instructions and the recording of the answers are as simple as possible, both for the respondent and for the teacher. After selecting the questions, the format of the questionnaire will be established: the appearance, the length and the way the questions will flow.

To identify talented students in mathematics, teachers use three types of questionnaires.

1. The first **questionnaire** is about **the lifestyle of teenagers**. This will allow teachers to learn more about how their students live, feel and think. The share of this questionnaire in shaping the profile of the talented student is **30%**.

2. The **second questionnaire** focuses on **the attitude of students towards Mathematics**, because we aim to identify students who want to perform in the subject of mathematics. The share of this questionnaire in outlining the profile of the talented student is **30%**.

3. Finally, the third and most interesting questionnaire aims to allow students (and teachers) to discover **the dominant types of intelligence**, something that will allow us all to improve the teaching and learning of mathematics for talented students.

The third type of questionnaire is developed based on **Howard Gardner's Theory of Multiple Intelligences**, which says that the individual is a unique amalgam of skills and talents, and memory or logic are not the only elements that define us. According to Gardner's theory, there are 8 types of intelligences: Visual-spatial intelligence, Linguistic intelligence, **Logical-mathematical** intelligence, Body-kinesthetic intelligence, Musical intelligence, Interpersonal intelligence, Intrapersonal intelligence, Naturalistic intelligence.

By applying the third questionnaire we aim to identify students who have a superior logical-mathematical intelligence, having pattern recognition skills, deduction and logical analysis of problems. For them, numbers, relationships and patterns turn into concepts.

Characteristics:

- **Increased problem-solving ability**
- **Inclination to abstract thinking**
- **Pleasure for scientific experiments**
- **Talent in solving complex problems**

The share of this questionnaire in outlining the profile of the talented student is 40%.

At the school level, the **Register of talented and gifted students in mathematics** is established.

Find below more information about identifying talented students in math by using the three types of questionnaires mentioned in the summary.

- J. **The DISCOVER Projects (Discovering Intellectual Strengths and Capabilities while Observing Varied Ethnic Responses)** began in 1987 under the direction of Dr. C. June Maker at the University of Arizona. At the time, Dr. Maker had been analyzing various new theories of intelligence, the most notable of which was Howard Gardner's Theory of Multiple Intelligences. She also had been studying groups of gifted children, as well as successful scientists who had overcome disabilities, to isolate factors contributing to exceptional success. She eventually determined that the most important component of exceptional success was the superior ability to solve complex problems. The DISCOVER Projects were created to study, categorize, and measure a broad spectrum of "problem solving strategies" used by various age groups of differing ethnic, economic, and cultural backgrounds.
- K. **Eby Primary School Recognition Tool. Teacher's Recommendation Form J. W. Eby** - The construction of the sheet is based on the definition of Renzelli's ability. It consists of three rooms: Abilities, Creativity, and Task Engagement. It consists of 15 items, 5 items for each of the scales. The teacher's task is to assess the test items according to the student's behaviour, which he makes by

marking the appropriate item on a 4-point scale, on its basis he calculates the total score.

- L. **Eby index of behaviour indicative of giftedness. General list of features of J. W. Eby** - The worksheet consists of a list of student behavior that the teacher may observe during various school situations. The theoretical basis of the tool is Gardner's concept of Multiple Intelligence. A separate form has been constructed for each of the six types of giftedness: linguistic, mathematical, natural and problem-solving, social and leadership, visual-spatial, musical and technical orientation. Within each of them, the presence of ten behaviors can be verified: perceptiveness, active interactions with the environment, reflectivity, persistence, independence, goal-orientation, originality, efficiency, self-esteem and effective communicating ideas. Each of them has two positions in the sheet. The teacher assesses on a 5-point scale.
- M. **David Lewis Parenting Test** - The sheet consists of 35 items describing the characteristics of a gifted child. The parent marks the behaviors and features that he recognizes in his child: a gifted child, Intellectual Skills, Leadership Abilities, Artistic Skills, Musical Abilities.
- N. **Teacher's questionnaire for observation of student Layock's skills** - The tool is used to diagnose the level of a student's skills in ten aspects: language skills, drawing conclusions, asking questions, originality of ideas, problem solving, pace of thinking, imagination, memory, observation, concentration of attention. They are assessed using a five-point scale: "poor" - "exceptionally good".
- O. **Recognition check kits scientific, artistic, creative talent, linguistic, mathematical, sports, leadership and organizational talent, G. Lewis** - The sets include 12-28 statements presenting the child's behaviour. Person the diagnosing person marks the frequency of the behavior (1-never, 5-always). The evaluation is constructed on the basis of the number of points scored, the higher the number, the greater the likelihood of a student having a talent.
- P. **Scale of Creative and Imitative Attitudes (SPTO) R. M. Sigva** - The worksheet is used to diagnose the level of creative attitudes and identify motivation features. The tool consists of two modules: identification and self-description. The first one includes 4 elements of creativity: divergent thinking, motivation, elaboration skills and attitude to failure in creative activity. The

second of these include strategies of students' coping with difficult situations, both in the Inter- and intrapersonal dimension.

Q. H. Gardner's Multiple Integration Questionnaire - The questionnaire consists of 28 statements covering the following areas: Linguistic, Mathematical-logical, Visual-spatial, Music, Interpersonal, Intrapersonal, Kinesthetic. The respondent performs self-assessment by marking a grade from 0 to 5 with each statement. The sum of points and marking it on the diagram determines the profile of the dominant type / types of intelligence.