THE DEVELOPMENT OF TALENTED STUDENTS

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Research during the XXth century beginning with Terman's work proved that talent is a complex concept, and numerous definitions and models have been developed since then. In all of them there are key factors like general abilities and special skills, and other environmental and social factors (school, family, social group). In schools the support of talented pupils is practically based on Renzulli's modell. Mathematical talent can be mostly developed during teenage and difficultly traced during the phases of development and change. The development of mathematical talent can also be enhanced outside formal school lessons in talent support camp for example. In my lecture I would like to present how to recognize, support it and further particulars of the experiences gained during our mathematics and physics-themed camps organized for the students of Comenius Grammar School (Zselíz, Szlovákia). We believe that the methods applied in the camps may be also succesfully used in the advocacy and support of talented students by other educators.

Keywords: development, talented students, math, identifying of talented students

Mathematical talent is perceptible in early childhood similarly to musical talent and tends to fade off in absence of proper developing. I am going to make a short overview of different concepts with a focus on identification and development of mathematical talent in the first part of my study. In the following part I am going to present some practical aspects and experiences of a complex talent development project.

Talent and exceptional skills were considered identical notions up to the beginning of the XXth century. *Terman* (1925) proved that talent is a complex notion and the definitions and models that have been drawn up contain several common elements. *Tannenbaum* (1983) considers equally important general skills and special abilities the way *Renzulli, Mönks and Czeizeldid*. Tannenbaum mentions „chance" as an individual factor, while *Czeizel* (1997) speaks about „fate-factor" in his 2x4+1 model. They all consider supportive environment a „crucial issue", mentioning family, society, culture and education. *Piirto* (1999) adds other factors: genetic, emotional ones. The notion of creativity introduced by Guilford (1950). Renzulli (1986) states that general and specific skills, high commitment and creativity are the three crucial areas. The so-called fate-factor turns up in

Czeizel's model (1997), which adds health and life-span to Mönks-Renzulli's model (Mönks & Boxtel, 2000) also underlining that the excedingly high results of what talented people are able, provides them with the feeling of contemptdness and succesfulness. *Gardner* (1985) puts an emphasis on the fields of natural, spiritual and egsistencial intelligence contrary to school-education that focuses on logical-mathematical and linguistic intelligence.

Diagnosing talent is not an easy task. Renzulli's model (1986) is adoptable to school pupils in educational environment. Cultural awereness, cricical thinking and problem solving strategies as well as social skills also need a careful consideration *Gyarmathy* (2007) draws attention to that.

Identifying, developing and development of mathematical talent

Mathematical talent can be detected at an early age, the highest achievements are reached during youth and there are few outstanding performancies after the fourties. Pupils who are very good at mental calculation can't be granted to be talented in mathematics during adolescent years (Perleth, Lehwald & Browder, 1990). After 12-13 a distinction between genders also shows up, probably due to males' better sense of number (Davis & Rimm, 1985) or out of other biological and cultural reasons and support is also pondered as influential factor in this respect. Mathematical talent implies specific thinking characteristics that have a weight during the development and improvement process.

Special features of mathematical thinking

Outstanding counting skills are due to exceptional work memory, figure memory, thinking ability and (or) a lot of practice (Perleth, Lehwald & Browder, 1990). But counting skills don't equal mathematical talent. There are two types of mathematical talent, the logical one and opposite to that the initiative one, characterized by visual thinking (ex. János Bolyai). *Reichel* (1997) calls these „the theory-builder" and „the problem- solver". The first one describes a phenomenon and fits it into a logical hierarchy, while the second one considers the problem from a new point of view. However these types are not „pure". Reichel (1997) mentions that talented mathematicians tend to work individually rather than in group and that's why personal consultations, tutoring is more effective with them than groupwork. Their main characteristics are listed by Gyarmathy (2002) as it follows:

(1) persistence and task-commitment,
(2) tirelessness during work
(3) they appreciate facts and formulas
(4) search for problems
(5) outsanding memory for numbers, formulas, means of problem solving
(6) flexible thinking and solving strategies
(7) easily alters thinking patterns
(8) ability to visualise abstract relationships
(9) ability to simplify complicated things
(10) fast formalising and generalising ploblems
(11) reacting to similar problems by leaving out logical steps
(12) looks for simple, straight and elegant ways of problem solving
(13) able to formulate and deal with verbal tasks through equations.

Identification of mathematical talent

Mathematical tests assess mathematical talent during early school years.Talented pupils present a considerable early interest for numbers, prefer puzzles,visual quizzes and systematically sort out things. *Stanley* (1990) and his team developed an assessment means for pupils called SAT-M in the USA. They assessed pupils with mathematical thinking above the average. Verbal skills varied a lot individually and pupils with both good mathematical skills and verbal skills did not necesserily become mathematicians (Gyarmathy, 2002).

New theories try to identify mathematical talent based on thinking processes as either (1) sliding easily from one subjective reality into other or (2) easily creating new subjective realities (Wieczerkowsky & Predo, 1993). Based on this, Hamburg Test für Mathematische Begabung identifies talented pupils using six factors (Wagner & Zimmermann, 1986)

(1) as they organize material
(2) recognition of patterns and rules
(3) restructuring tasks and repeated recognition of patterns and rules
(4) understanding and using highly complex structures
(5) processing indirectly and reversally
(6) finding connected tasks

Effective and recently elaborated tests have the following common features (Gyarmathy, 2002):

(1) they identify early interest in visual games and quizzes
(2) joining talent development programmes when objective common school results, other tests and interest for maths are scored
(3) presenting a boad task-solving repertoir
(4) use of geometrical tasks, memory tests and testing visual skills
(5) Raven-test can be used effectively
(6) use of highly effective means for problem solving.

Developing of mathematical talent

Development of mathematical talent can be attained both in school or out of it during speeding up an enriching programmes. Pupils can aquisit more material in a shorter time or are offered more difficult task-solving ways and more additional knowledge. The first means in considered really effective and productive when started before school years and in summer camps for several weeks. In Germany the most talented 20% of pupils are chosen and trained in a special program for 25 weeks. There are small group activities (geometry, permutations, graf theory) and the purpose of this training is development of problem solving strategies (Wagner & Zimmermann, 1986).

Although Hungarian educational system considers talent development a basic task of school teaching, there are other ways to work on this. We can mention camps, competitions, study circles, magazines and personal relationships with scientists and contact with groups.

This paper presents our experiences gained during four consequitive Maths' Camps organised for talented pupils building up a complex development process of logical thinking, visual skills, mathematical knowledge, creativity and social skills altogether.

These summer camps had evidently had a positive effect on pupils' learning results, competition scores and personality. The former students of the *Comenius Secondary School in Zselíz, Slovakia* continued their studies at different Universities and took advantage of this extra developing and improving opportunity. The summer camps were organised in years 2004 and 2005 in Kovácspatak 8 days, in 2006 in Csiffár for 5 days, in 2008 in Ipolyszakállas for 4 days.

Daily schedules: 7 am getting up, exercise, tiding
8 am breakfast
8.30 am to 10.00 activity
10.30 am to 12.00 activity
12.30 lunch
13.00 pm -15.00 pm free time or sport activities
15.00-18.00 pm compeeting
18.00 pm dinner
19.00 -21.00 games, quizzes, strategic games, films
22.00 end of day

Pupils were 10 to 18 years old and 4 teachers worked in shifts with 4 groups of pupils paralelly all during the activities (Kinga Jalsovszky-Horváth, Krisztián Šoóky, Imre Kuczmann, Erika Rozália Vígh-Kiss).

Advantages of camp-work

Traditional Math lessons usually follow a routine – presentation of a new topic, statements, sometimes without demonstration, instruction of methods comes, and drilling for the end. This routine often puts pupils in the position of passive receptors.I it is sure that traditional teaching practice improves major competences rather than group work, cooperation, argumenting, critical thinking, creativity, empathy and problem solving thinking.

It is also evident that other methods like Hobo, Gordon, heuristics, brainstorming, project-based teaching and discovery-aimed method (see Tamás Varga) enhance problem-solving thinking and turns pupils into active explorers of new knowledge. This process motivates pupils for independent and individual work. Teachers have to pay attention to outline clearly the tasks and expected results, and to be sure that the level of task-difficulty doesn't surpass the level of pupils' knowledge. The activities have to be carefully prepared so that they shouldn't frustrate pupils and decrease motivation. The use of the methods mentioned above needs time, pupils cannot be rushed. New strategies have to be practiced, triald andbuilt into each pupil's cognitive web, connected to already aignired elements, conceptions and notions.

We consider mathematics' camps a very proper ground for such discovering and exploring learning methods also resulting into flow experiences (Pósa, 2001). In spite of the fact that most pupils taking part in these camps were talented, motivated ones, with good academical results, it proved necessary to organize groups of 3-4 with similar levels of knowledge and to avoid turning activities into competitions. We also suggested to work at their own pace without strict time limits when pupils had difficulties with concentration or got tired. When groups had finished work they gathered and listened to each other, argumented different solving strategies and explained their ideas. They could also make up other similar tasks. The main fields of mathematics that we explored and found raising interest were: diversibility, numerical systems, graf-theory, combinatorics, probability theory, geomety, and even historical presentation of maths as a science.

Another aim of the camp was to prepare pupils and students for competitions. They took part in regional competitions such as *Pitagorasz, Math Olimpics, Ilona Zrínyi Competition, Gordiusz, Kangoroo and Klokan*. They also participated successfully in correspondence competitions both in Hungary and Slovakia in both languages. (I can mention here *Katedra, TIT, KöMaL, Genius Logicus, MAKS*.) We used to train our students for these sort of tasks not only during camp activities, but also at school at afternoonr lessons or individual consultations.

Through we made up a detailed schedule for the lessons and tasks, we could afford to alter the pace of our work and to vary methods and strategies in order to fit the reguirements and the disposition of our students during the camp wtihin four hours of maths lessons. This proved quite effective. Manual skills were being developed by handcraft activities and lessons began and ended with tasks to strenghten memory and observation. Quizz questions, number crosswords and logi-stories, proved to be popular even for relaxation periods. (I could find lots of them in Lajos Pósa camps and Róka' task collections.) Pupils were offered three difficult problems every afternoon to be solved till next day.

I. Several examples:
- What' s the total of –8, –7, –6, ..., 6, 7, 8?
- How many numbers egual their opposites?
- How can you devide a cylinder-shaped cake into eight egual parts by three cuts?

II. Is there a three-digit prime number of which digits result ten when being multiplied.

Key: The three digits are 1, 2, 5. The last digit can never be 2 or 5. Possible answers are 251 and 521.

III. What is the total of all the six-digit numbers in which only number 1 and 2 can tur up?

Key: The good two-digit numbers: 11, 12, 21, 22, so the result of digits in six-digit number is $6 \cdot 11= 66$. The good three-digit numbers: 111, 112, 121, 122, 211, 212, 221, 222. If this numbers we write into colums above each other ??????????, the result of digits in each positional notation (=helyiértéken) is 12, so $12 \cdot 111=1332$. Six-digit numbers include $2^6=64$ numbers. By listing these numbers in a column they will result $32 \cdot 1+32 \cdot 2= 96$. The total will come out like that

$96 \cdot (10^5+10^4+10^3+10^2+10+1) = 96 \cdot 111111= 10\,666\,656$. This task teaches students to use strategies during work, to row numbers and find a system.

IV. Prove, that $4 = 5$.

Evidence: Suppose, that $a = b+ c$.

So $5a = 5b + 5c$

and $4a = 4b + 4c$

Using the eguations we add up $5a + 4b + 4c = 5b + 5c + 4a$.

By substracting 9a we come to:

$4b + 4c – 4a = 5b + 5c – 5a$.

Than

$4(b + c - a) = 5(b + c – a)$

At last dividing by $(b + c –a)$ the result will be $4 = 5$.

Key: We presuppose that $a = b + c$, so $b + c – a = 0$.

But can we divide by 0?

Condgames, boardgames and the logi-kit proved motivating and offering constant intellectual challenge because rules of the game can be varied and some additional knowledge can introduced such as topology, minimal surfaces (one of our guest at the camp was Zoltán Kovács who tought 20 different games to our students in two day some of which go, hexagonal chess, tower of Hanoi became popular.

Developing divergent thinking

According to Piaget the aim of teaching is to educate people who are able to create new things, who are creative, curious and inventive by offering and forming a background and a learning environment to make possible the development of these skills. What are the proper circumstances to develop divergent thinking?

Firstly, pupils need emotional safety, uncornditioned acceptance, the increase of self-respect and possibility of self-evaluation, teacher should be able to accept their points of view. Pupils must be self-confident enough to try new things. Secondly the teacher's attitude must be supportive, show patience and interest in pupils ideas. In addition, of course, teachers need material and tasks that readly ehance divergent thinking and there aren't many of these in manuals. *Horváth* (1997) workbook offers some of these. (ex.: Divide a square with sides of 13 cm in other squares of different sizes, the sides should be whole numbers).

Strategic games are also good means to develop divergent thinking and they have the advantage to give a sense of achievement by gradually increasing their grades of difficulty. Chess, abalone, blocus, morris are strategic games that are both enjoyable and develop combinatoric skills, strategic thinking, sense of space and direction and persistence. Some of them connect to geometrical notions like point of intersection and line of intersection.

Free-time activities

The camps were also a proper occasion to focus on personality development and to strenghten physical skills. Sports were a constant element during camps (swimming, football, bedminton, table-tennis), obstacle-race, number-wars and adventure-games need self-confidence, initiative and creativity and also team spirit.

Some other activities that added colourfullness to our palette were: drawing, acting out jokes, reading anecdotes about famous mathematicans, IQ-quizz, Tangram team-competitions, handcrafts, museums, watching nature-films and popular science films. For a closing a camp-fire and evaluation discussion is not to be left out.

Summary

Math-Physics talent development camps need a detailed and sometimes exhausting preparation and planning but they offer unforgettable experiences for students and teachers and circumstances that can hardly be equalled by classroom-work. The active, various and enjoyable „camp-life" gives them the feeling of freedom, joyfulness and successfulness and is a source of intellectual curiosity. Pupils and students experience the rewarding feeling of creative work, intellectual challenge and freedom.

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