IT-Giftedness in Children and Adolescents

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ABSTRACT

IT-giftedness represents abilities related with widely differing uses of information technologies (IT). Children and adolescents often exhibit surprising abilities in the use of computers. At the same time they face educational and psychological problems. We hypothesize that typical adolescent problems with IT will be lessened if a dynamic approach to giftedness is applied. We analyze the intelligence, social skills, and personality traits of professional software engineers. We then analyze how these might be more easily acquired by IT-gifted children and adolescents.

Keywords
Adolescent IT abilities, Child development, Information technologies, IT-giftedness

Introduction

Some economists might suggest that the major world capital is finance. A technocratic view might imply that the major world capital is a combination of natural resources and technologies. An environmentalist might argue that the major world capital is ecology. A humanist might suggest that the major world capital is education and the development of giftedness. These perspectives are not necessarily exclusive.

This paper concentrates on a specific aspect of children and adolescents’ giftedness, namely on abilities and competence in IT use. We adopt traditional methods pertaining to diagnosis and support of the gifted and talented. We then focus on IT-giftedness as a new area of interest about which we propose a dynamic perspective with regard to its analysis.

Evaluation of Giftedness: Change of Paradigms

We review briefly both early views and modern approaches to giftedness. From the very beginning of the 20th century, the psychometric approach dominated. The most influential contributors in the area were Charles E. Spearman, Louis L. Thurstone, and Joy P. Guilford. Traditional intelligence and capabilities tests are grounded on the psychometric approach.

Two positions are widely discussed. The first is the theory introduced by Spearman (1904) that maintains that two factors determine success in problem-solving: the general G-factor and the special S-factor. The G-factor is believed to direct any kind of mental work and to guide subordinate special abilities. Being mostly latent, the G-factor is difficult to specify. Efforts by Spearman and other researchers (Cattell, 1971; Eysenck, 1988; Raven, 1960) did not result in an empirically-based description of the two-factor structure of human abilities.

Alternative multi-factor theories were proposed. First, Thurstone (1938) described seven primary factors and argued that no single IQ score measured intellect or mental abilities. Later positive correlations were found between some factors, and second-order factorization showed a tendency to form a generalized factor (Brody & Brody, 1976). Methodologically, the opposite theories might reduce to one global approach, but the multi-factor theory got new theoretical and empirical impulse from Guilford (1967). Starting with the factorial structure of intelligence (SOI), Guilford predicted up to 150 independent factors; he described two thirds of them and worked out – with his followers, especially Torrance (1974) – numerous tests.

This theoretical construction and its practical realizations are being heavily used by school educationalists and psychologists. Intense practice of testing abilities made it clear that the psychometric approach meets serious problems. We will indicate briefly three classes of problems.
The first lies in the methodology of factor research. Rotation – a common technique of factor structure analysis – using Procrustes programs to adjust the resulting structure to the underlying theoretical data depends on subjective ideas of ease of use and correspondence to the theory (Cattell, 1971; Horn & Knapp, 1973). Thus, Guilford’s SOI gets no fundamentally based experimental confirmation.

The second derives from observations that psychometric measures are static, and abilities are developing in diverse tempo: child prodigies oppose to late bloomers. In time dynamics considerable changes of giftedness indicators (e.g., IQ scores) – up to 50 points – may take place (Bradway & Robinson, 1961).

The third is the belief that early differentiation contradicts democratic values. People might reveal their talents late; on the contrary, many of those labeled as talented ended their lives as underachievers. Younger generation needs support, not labeling as gifted or less gifted; besides, there are known cases of inaccuracy in diagnostics.

Approaches towards carrying on research on giftedness have changed. Earlier, the emphasis on cognitive nature of giftedness left underestimated the contribution of motivational and emotional characteristics, of cultural, societal and environmental influences. Major impulse for changing the paradigms came from the Gardner’s (1983) theory of multiple intelligences. Motivational aspects of creative actions are stressed (Collins & Amabile, 1999), as well as emotional intelligence (Mayer & Salovey, 1997; Bar-On & Parker, 2000). Earlier, the latter was investigated in Russian psychology (Tikhomirov, 1988).

The methodology of giftedness research is undergoing (r)evolutionary changes. Phenomenology and qualitative methods substitute psychometric methodology. The updated research procedures include case studies, surveys, biographical studies, interviews, narrative methods, dynamic testing, etc. (Csikszentmihalyi et al., 1993; Simonton, 1984; Winner, 1996).

The renewal of methodology is accompanied by updating the scope of giftedness. Parallel to social and technological progress, and in accordance with the development of children’s interests, the nomenclature of giftedness embraces new domains. In the former Soviet Union, for example, training centers for selection and extracurricular education of gifted athletes, classical ballet dancers, chess players, musicians, etc. were organized. The nomenclature of giftedness has been widened: additionally to music, science, mathematics, athletics, dancing, visual and verbal arts, giftedness in social leadership (social giftedness) is now being distinguished and investigated (Abroms, 1985). Though the scope of giftedness will never include every human virtue and/or value, the authors believe that it should be widened in a reasonable way.

Dynamic Approach to the Development of Giftedness

The fundamentals of the modern approach to giftedness research and practice were first stated by Russian psychologist Vygotsky (1962; 1978). Vygotsky argued that giftedness is characterized by high heterogeneity. The essential part of Vygotsky’s theory emphasizes the dynamic development of abilities (Babaeva, 1999). Recently Vygotsky’s ideas are receiving recognition outside Russia. The main points of Vygotsky’s perspective that we adopt are:

- High intellectual development is not an index of giftedness since extraordinary achievements are possible with average cognitive abilities. Motivational and emotional factors, personality traits, atmosphere in the family, societal and environmental influences should be taken into account.
- There are manifold kinds of giftedness, including hidden talents. Each of them requires specific diagnostic techniques and methods of development.
- Instead of quantitative estimates, qualitative analysis of giftedness should be practiced. It is important to retrace an individual path of development.
- The range of abilities which are to be diagnosed should be broadened to embrace various activities which may reveal the student’s potential.
- Promotion of the development of giftedness is an issue of primary importance. Diagnostics of abilities should not label a student as gifted or non-gifted. Diagnosis should lead to recommendations for children, adolescents, their parents and teachers.

This paradigm of the development of giftedness makes it possible for psychologists and educationalists to broaden the study of abilities children and adolescents exhibit, and to make recommendations aimed at high achievements. It is important to explore hidden or latent forms of giftedness and to help a child or adolescent to overcome possible shyness or indecisiveness to demonstrate abilities openly.
Broadening the Nomenclature: IT-giftedness

Competent use and abuse of information technologies by children and adolescents

The value of competent computer use and software development is widely discussed in educational theory and practice. Most research on the development of abilities in IT use was done since classical works by Papert (1980) and Turkle (1984) were published. Nevertheless, though almost every school-teacher can name students who are exceptionally good in computers, only rarely these students get competent tutorship.

Probably the most needed direction of guidance lies in the universality of ethical behavior. The “never-do-harm-to-others” rule is difficult to follow in unknown environments, and mediation by the Internet is a new environment. Younger generation may have not enough experience to qualify harmful or illegal actions as unethical; instead, these are called “funny”.

The mainstream of computer security is modernization of security systems. To the authors’ belief, it would be no less pragmatic and less expensive to work out methodical guidance (plus training courses) and distribute it among teachers and parents (Babaeva & Voiskounsky, 2000). Special classes or home explanations on the practical IT ethics might give greater effects than firewalls and crypto systems. To the best of the authors’ knowledge, an initiative of educating children in fundamentals of the IT ethics (also called cyberethics) comes from the Cybercitizen Awareness Program (http://www.cybercitizenpartners.org) founded by the U.S. Department of Justice and the Information Technology Association of America. This experience needs to be broadened.

IT-giftedness: Discussion of its nature

Proposing IT-giftedness, or giftedness in the use of Information Technologies, we need to consider specific features characteristic for any sort of giftedness, namely above-average level of achievements, creativity, perfectionism (the strive for high standards), and specific (usually intrinsic) motivation.

The importance of high achievements is clear from the definition of giftedness produced by the US Congress on October 15, 1978:

Gifted and talented children means children, and whenever applicable, youth, who are identified at the preschool, elementary, or secondary level as possessing demonstrated or potential abilities that give evidence of high performance capability in areas such as intellectual, creative, specific academic, or leadership ability, or in the performing and visual arts, and who, by reason thereof, require services or activities not ordinarily provided by the school (Silverman, 1982, p. 172).

Above-average abilities and/or results are crucial for being selected as gifted. Few men of genius demonstrated exceptionally high results during school-years: one needs time to master the domain. Researchers introduce the “ten-years rule of mastering” before highest achievements are gained: “Even Mozart did not produce his first masterpiece until after about ten years of composing” (Winner, 1996, p. 293). Adolescents demonstrate high-standard achievements in the IT field, comparable to the ones gained by adult professionals. This is characteristic for the mastering stage of the IT use (Turkle, 1984). The IT field is prospective for gifted students’ early start towards high achievements and for outdating the ten-years term (Babaeva & Voiskounsky, 2000).

Creativity is a fairly new research area, with diverse theoretical standpoints; besides, a lot of practical work in creativity is being done outside academic psychology or educational theory (Sternberg & Lubart, 1999). The essence of creativity is generation of novel ideas and openness to innovations. Winner differentiates “little c” creativity – that means, children “discover the rules and technical skills of their domain on their own, with minimum adult scaffolding, and often invent unusual strategies by which to solve problems” (Winner, 1996, p. 279), and the “big C” creativity – “stretching, altering, or even transforming a domain” (ibid.).

Many children and adolescents enjoy the reputation of “computer wizards” and exhibit much “little c” creativity. But how about the “big C” creativity? Winner believes that “when domains are changed by children, it is only because an adult connected to the domain recognizes something of value in children’s work and is influenced by it” (ibid.). Thus, the responsibility of accepting adolescents’ suggestions lies on professionals. Independent as they are in inventions, Creative (in the “big C” sense) children and adolescents depend on adults’ opinions.
Perfectionism is characteristic for the gifted and talented. In the IT field, any work done according to the highest standards is enthusiastically appreciated. For “hard style” masters (Turkle, 1984), or “explorers” (Shotton, 1989) every piece of software they work on is a sort of challenge. Respect from the competent others increases their self-esteem; very often misunderstanding and underestimation from the less competent mates and/or adults do not lessen this mark.

Gifted students' motivation, or task commitment, in Renzulli’s (1977) terminology, is undoubtedly important. Many schoolchildren have strong interests in creative IT use, demonstrate high immersion and little interest in possible rewards. This motivation – “to engage in an activity primarily for its own sake” (Collins & Amabile, 1999, p. 299) – is called intrinsic. Fabulous ease of learning, familiar to gifted students’ teachers, often derives from intrinsic motivation. This motivation is close to the notion of flow: one feels absorbed with the problem, loses sense of the outer world, and experiences a state of being pleased or happy (Csikszentmihalyi et al., 1993). At the same time, flow is not just fun, it accompanies hard and productive work.

We believe IT-giftedness is an unstructured family of abilities. Probably high competence and above-average achievements in writing computer software are the most important. Throughout the paper, this activity will be called computer programming, or software engineering, or software development. But for computer programming, the IT-gifted should be somehow competent in OSs, in programming languages, in software applications, in microelectronic devices, in telecommunications and cable connections, in information seeking on the WWW, etc. They might be exceptionally creative in some areas and less competent in others. Web design abilities might be closer to an artistic kind of giftedness than to IT-giftedness.

Competence in computer science can be compared to the average high-school student’s knowledge. Computer programs only rarely can be evaluated in the same way, since in most countries school-age children either are not required to compose programs, or write rather simple programs. Whenever the programs surpass the level of mediocrity, their authors (either getting special instruction, or self-taught) might be suspected as IT-gifted. A fairly good way to evaluate computer programs developed by possibly gifted children is to compare their programs to software products of adult professionals. To compare, standard evaluation criteria might be used, which are not too numerous. Evaluation procedure might possibly rely on the Cognitive Dimensions Framework of 14 features (Green & Petre, 1996).

**Brief Literature Overview on Human Factors in Computer Programming**

Although to the best of the authors’ knowledge, there are no special sources on IT-giftedness, one can come across relevant data in diverse publications. We limit the discussion to major features of successful professional programmers, and that means, to adults. IT-gifted children and adolescents might succeed if acquire some qualities and abilities of professional software developers.

Empirical sources are not numerous and are mainly restricted to teaching programming to students or to comparison of novice programmers and experts. Curtis (1986) pitifully stressed that empirical work rarely deals with highly qualified programmers. The majority of publications is based on (and restricted to) cognitive approach to software development. Particularly, we might mention some monographs (Sackman, 1970; Shneiderman, 1980; Wender et al., 1995), six volumes under the heading “Empirical Studies of Programmers” – the first (Soloway & Iyengar, 1986) issued in 1986, the last Gray & Boehm-Davis, 1996) in 1996, and proceedings of conferences organized by the Psychology of Programming Interest Group (http://www.ppiig.org).

Since we believe that programmers’ motivation, social skills or personality traits are as important as cognitive abilities, we refer to non-empirical publications and experts’ views. Useful sources include: volumes on software psychology and educational practice (Hoc et al., 1990; Shotton, 1989; Turkle, 1984; Weinberg, 1998), some books on software management (Brooks, 1995; Grady, 1997; Wiegers, 1996), and non-cognitive research papers (Curtis et al., 1986; Smith, 2000; Sonnentag, 1995; Strizenec, 1973; Weinberg & Schulman, 1974).

**Dynamic Approach to IT-giftedness**

The dynamic approach to IT-giftedness includes the following directions of research and practical work in the area:
- diagnostics of IT-giftedness,
- effective use of IT to foster education and development of IT-gifted students,
neutralization of negative effects of IT use by IT-gifted persons.

We will discuss the first point; the others are discussed elsewhere (Babaeva & Voiskounsky, 2000). Known efforts to diagnose IT-giftedness concentrate on the development of intelligence. It is widely recognized that programmers make plans and work systematically, require high-level verbal and non-verbal intelligence, cognitive flexibility, critical thinking, advanced abilities for abstractions and interrelations, readiness to update knowledge, etc. But for intelligence, software engineering requires fairly good social skills, and sets certain demands on personality traits. Thus, research in computer programming is a combination of cognitive and personality psychology.

**Intelligence and intellectual abilities**

Psychometric tests evaluate overall intelligence and special abilities, but what are the proportions for software design? Use of tests to select computer programmers was reported forty years ago (McNamara & Hughes, 1961). Later, specialized tests (Computer Programming Aptitude Tests/Battery, Electronic Data Processing Test, Computer Science Aptitude Test, etc.) were composed but gave no success (Shneiderman, 1980). Measures of general intelligence are more prognostic (Besetsny et al., 1993; Neuman & Nomoto, 1990; Schmidt et al, 1980).

Test designers assume that effective computer programming correlates positively with academic achievements in mathematics (Coates & Stephens, 1990; Overton et al, 1997; Zickar et al., 1999). Though some findings confirm the assumption (Dudgale, 1994; Oprea, 1988), this commonplace view is questionable.

Programming has little to do with mathematics, but for specific applications (Tseitin, 1979). For Ershov (1972) constructive engineering abilities and aesthetic views are as important as logical reasoning and mathematical abilities. Turkle (1984) characterizes the “soft” programming style as pursuing fantasies, switching between program modules, and making decisions on aesthetic grounds. Knuth insists that computer programming is art (Knuth, 1974).

These opinions were declared decades ago. Since that time the profession has changed. At present, programming is close to an end-user who might lack advanced mathematical education. Thus, diagnostics of programming abilities need not restrict to mathematics and logics. Software developers require more miscellaneous skills, knowledge, abilities and habits than specialized aptitudes tests measure.

Besides, talents and abilities develop. Dynamic approach to diagnostics does not mean putting labels (gifted/non-gifted). Instead, a student should get a recommendation of sideways to attain success in IT use – to enhance intrinsic interest, get additional training, join a group of competent students, etc.

**Social skills**

Typically, people think programmers work alone and are introverts. Nevertheless, Yourdon (1975) stated programmers need good communicative skills. These include, but are not restricted to, collaboration with colleagues, managers, and clients/users/customers. Really, research on programmers’ groupwork goes back to 1960s (Brooks, 1995; Weinberg, 1998; Weinberg & Schulman, 1974); prototype systems are tested on customers, which means intense communication; XP, or extreme programming is a recent trend: programmers design, code, debug, etc. in pairs (see [http://www.extremeprogramming.org](http://www.extremeprogramming.org)).

Social skills often correlate with programmer’s experience: the best programmers took part in diverse projects, and consequently, in many group meetings (Sonnentag, 1995). Good social skills (besides professional knowledge, proficiency and motivation to work) increase chances to be employed. Abilities and willingness to explain one’s actions to managers, to understand colleagues and help them, and to satisfy the client’s curiosity would enable a programmer to join a team.

Easy to anticipate, social giftedness may not accompany IT-giftedness. The degree of popularity, the amount of friends, the number of daily/weekly/monthly encounters are indicators of social skills. Abilities to carry on face-to-face and computer-mediated contacts might be developed through training. This is the standpoint of the dynamic approach to the social-skills-development of the IT-gifted.
**Personality Traits**

Personality traits and programming efficiency might correlate (McNamara & Hughes, 1961). Weinberg (1998) and Shneiderman (1980) put forward seemingly appealing traits: assertiveness, tolerance, self-esteem, locus of control, persistence, aspiration and anxiety levels, etc. The Myers-Briggs Type Indicator (MBTI) was first recommended (Shneiderman, 1980) but argued to be irrelevant (Pocius, 1991), then found useful (Whitley, 1996).

Ershov (1972) states programmers are emotionally stable, intrinsically motivated, punctual, show fantasy in mathematical abstractions, cope with routines and rigid design sets. Software developers – the most qualified ones (Dolnykova & Chudova, 1998) – report they feel like constructing alternative worlds: “objects of interlocking moving parts … work in subtle cycles” (Brooks, 1995, p. 7). Imaginable worlds function in complex environments, are fully comprehensible, make sense (Smith, 2000). These are built here on Earth – first within the profession (open sources, anti-copyright, free software movements, the GNU and Red Hat projects, etc.), then within larger communities. To improve the society, some programmers support marginal movements, esoteric or radical groups.

Not many (if any) professionals possess personality traits reportedly needed to succeed in computer programming. The profession is changing rapidly; diverse personality types adapt to changes. The dynamic approach proposes methods of smooth adaptation to IT, of keeping balance between the imagined and the physical setting.

**Conclusion**

The field of children and adolescents’ giftedness is undertaking renovations in methodology and nomenclature. Educators and psychologists should not turn their back to the young people exhibiting phenomenal abilities in computers and the Internet use. Investigation in IT-giftedness should result in proper shaping the horizons of technological progress, and in proper tutoring the “computer wizards”. In parallel, a dynamic approach to giftedness is developing. This approach is prospective for dynamic entities, and the area of IT-giftedness is accelerating step by step with the IT development.

The dynamic approach should take into account social skills, intelligence and personality traits of the IT-gifted. IT-giftedness as a research field and area of practice combines the methodology of both the personality and the cognitive psychology. Research and practice in this new field is a challenge.

**References**


