From Mathability to Learnability

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***Abstract*—The notion of Mathability introduced by P. Baranyi and A. Gilányi in 2013 has evolved though the years and broadened the range of its meaning. Taking technical revolution and skills demanded by the labor market into consideration, learnability of the young generation is described as a natural extension of those procedural ways of learning which were worked out by problem solving, data processing, programming etc. Namely, mathematical abilities and cognitive infocommunication templates are presented as necessary tools and foundation for life-long learning.**

***Keywords*—Mathability; Education; Constructive Learning; Cognition; Cognitive Infocommunications; Cognitive Templates; Digital Competences; Key Competencies; Learnability; Life-Long Learning.**

INTRODUCTION

P. Baranyi and A. Gilányi, in the paper [4], introduced the concept of mathability as a branch of cognitive infocommunications. According to the definition it investigates any combination of artificial and natural cognitive capabilities relevant to mathematics. The authors included into the notion a wide spectrum of areas ranging from low-level arithmetic operations to high-level symbolic reasoning (see also [2] and [45]). Throughout the recent years, educational aspects of the concept were intensively investigated (cf., e.g., [2], [6], [7], [8], [14]–[29], [40] and [44]). Moreover, its relation to computer assisted solution of mathematical problems was considered (among others, in [11], [12], [13], (cf. also [33], [34]), [31] and [32].)

A deepened discussion implied a question about the future of mathematical education. In the age of technical revolution and smart devices aiding processes of making decisions, statistical inferences, complex calculations, deriving formulas, etc. (investigated, from several point of view, among others, in [10], [30], [35], [36], [37], [40], [41], [42] and [43]), it is reasonable to ask how deep one has to know and understand the foundation of mathematics in order to apply modern machines with high mathability level to solve problems related to mathematics. Several researchers examined how students can use mathematical application, computers and other machines to compute partial results necessary to solve complex problems in a case that they do not fully understand complicated definitions (for specific examples and explanation we refer to [17], [19] and the references therein). We can ask the same questions in relation to the foundation of knowledge of other sciences. In fact, all the conclusions worked out formerly for mathematics turned out to be valid for education of all sciences and engineering subjects.

Our aim is to build a model of education aided by high mathability level devices as well as by any other machines and smart device, a model compatible with young people cognitive templates. In order to achieve the goal we have already investigated (cf. [16], [17], [18], [19]):

– most important skills demanded by the labor market,
– learning styles and cognitive templates of pupils and students, also with comparison to learnability of adults,
– taxonomy of learning outcomes adjusted to a constructive learning style,
– constructive learning and teaching methods.

In this paper we would like to present how methods and technics as mentoring, edu-coaching and tutoring are combined with soft skills trainings, and we intend to show the importance of this combination. The paper also serves as a broad introduction to some further research on various activating methods of learning supported by multimedia and various ICT tools, for examples in an alternative after-classes school system. We note that the areas considered: mathability and ICT aided learnability are intensively investigated branches of cognitive infocommunications (CogInfoCom) (cf. [2], [1], [3] and [5]).

I. SKILLS DEMANDED BY THE LABOR MARKET

Following the report Responsive and responsible leadership of World Economic Forum in Davos reports (cf. `https://www.weforum.org`), we conclude that modern workplaces can be described by:

– dynamic development of ‘smart’ technology facilitating variety of processes,
– computerization,
– creating super-structures in organizations,
– new eco-system of media, where social media are the most important onces.

These changes enforce training new competences of employees. Among the most important abilities we can list:

– an openness towards changes,
– self-improvement and development,
– creativity,
– creative problem solving
– and critical thinking.

They are forecasted to be the most demanded skills on the labor market in 2020 and later. According to an article the Head of Services Central and Eastern Europe (CEE), Microsoft, Norbert Biedrzycki (published by Forbes in June 2019 with the title 'Uczmy się jak maszyny, a nawet bardziej'; also available at `https://www.forbes.pl/opinie/uczmy-sie-jak-maszyny-a-nawet-bardziej/dpzl0gr`) the list can be completed with:

– human resources management,
– team cooperation,
– emotional inteligence,
– concluding and making decisions,
– negotiation,
– cognitive flexibility.

We can conclude that the 'hard knowledge' has been losing its leading value. Automation and intelligent technologies will convince student to learn continually in order to take part in life-long learning and guarantee a permanent and satisfying employment. Then, not remembering but immediate selection, evaluation, data processing and ICT aided making decisions will become a crucial human abilities. This is why the application of Mathability methods in education (see: [16], [19]) could be and should be widely applied in any field of science.

II. Learnability of the youth

The dynamical change of labor market makes us construct an educational system based on constructive learning aided with smart devices. First, we should take into consideration cognitive templates of pupils and students. In [19] and [17] we proposed a model of constructive learning including:

– assimilation knowledge
– searching for the knowledge and examples,
– understanding notions, methods, examples,
– following the methods used in the analyzed solution,
– finding a solution of the original problem,
– reflection and assessing the result and method.

It is necessary to be aware of some risk following the youth habits born by an easy access to information and smart devices. Namely, essential reading of hypertexts, searching for keywords and immediate matching, comparing and concluding, is followed by satisfaction with a sketchy solution, not understanding neither the core of the problem nor its solution, not reflecting on the obtained result ([17]). Moreover, the majority of students uses the easiest accessible sources of data, not exploring the essence of the content. Since students remember mostly the part of knowledge they discovered on their own even, it causes superficiality of their knowledge even if they are given more detailed and advanced information and explanations (read more in [19]).

In order to meet requirements of the labor market, using natural abilities of the youth and avoiding the above described risks we proposed a taxonomy of learning outcomes (cf. [17]) compatible with a well know Bloom's taxonomy (cf. [9]) and Kolb's learning cycle (cf. [38] and [39]). Kolb's cycle is frequently used in education of adults. In [17] we expained how valuable it is to apply the cycle to the constructive education on the school level and considered constructive teaching methods based on the knowledge gained by students on their own, and methods of non-mentored constructive learning.

The above investigation resulted in a description of the following constructive way of building knowledge:

1. Students browse knowledge sources, search for information and examples. The step stands for Bloom's stage of 'remembering'. Since information is easily accessible, young people do not feel the need to memorize it. In Kolb's cycle we could compare the step to the stage of a 'concrete experience'.
2. Students evaluate and select appropriate information fitting the prior knowledge system, understandable and credible. Unfortunately, this step is frequently omitted by students what causes with building a false foundation for further education. Two of Bloom's stages are consistent with this step: 'analyzing' and 'comprehending'. It also corresponds to Kolb's 'observation and reflection' stage.
3. Students assimilate the new knowledge into the prior knowledge system. They build analogies, search for relations, and conclude. They can try to repeat the new knowledge with other examples of usage. For instance, if they learned an algorithm they try their own computation with other data. The step corresponds to Bloom's 'applying' and Kolb's 'testing the concept'.
4. Students interpret new knowledge, since they have just gained new knowledge or experience. That is adequate to Bloom's 'synthesizing'.
5. Students reflect on an overall result, evaluate new knowledge or methods, what is similar to Bloom's 'evaluating' stage.

The last two stages can be compared to the stage of 'forming abstract concepts' in Kolb's cycle.

From that point the cycle starts again from the beginning since new questions should arise and make students search for more information and new methods. So, they construct their knowledge by discovering, problem solving, experiencing or giving new meaning. Analogous cycle for learning abilities is constructed and described.

III. Fututure investigation

Technical revolution has influenced competences demanded from school and university graduates. On the other hand, it has modified learnability of pupils and students. Thus, in general, education must follow the changes and new activating methods, which response the youth cognitive abilities and atract their attention. Simply, we can illustrate a personal education as a process of transforming information with algorithms of making decision, building databases, adjusting procedures and deriving formulas. It shows how the theorx briefly called Mathability can be extended to general Learnability.

In the nearest future we would like to present some mentoring methods useful for constructive learning of students. It should be noticed that the presented system replaces the leading role of teaching with by the crucial role of learning. Among the methods we will show some theory and examples of application of edu-coaching, tutoring, soft skills trainings and networking (more in [15], [19]. It is worthwhile to notice that the method improves not only knowledge and scientific skills but social abilities as well.

A great opportunity of taking part in an educational project involving about 500 Polish schools of each level, acretes an arena for a deep and broad research thanks to which we will be able to:

– observe leaning templates of the youth,
– discover new interactive, constructive methods of learning based on the observed templates,
– prove effectiveness and advantages of the proposed methods.

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