Towards "Learnability"

What we benefit from Mathability

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Abstract: Mathability in its definition, refers to cognitive infocommunication and combines machine and the human cognitive capabilities that are essential for mathematics. Through the years, the notion evolved and its methods turned to be applicable for self-education and constructive learning. In this paper, we would like to investigate how some of the methods can be practiced to meet requirements of the contemporary labor market, especially if we consider as an aid of ICT.

Keywords: Mathability; Education; Constructive Learning; Learning of Adults; Soft Skills; Activating Methods; Edu-coaching; Activating Educational Method; Life Long Learning; Self-improvement

Introduction

Contemporary labor market, called *Anytime, anywhere*, its dynamic changes as well as features of the Millennials and the next generation, make personal development methods more and more valuable already at an early stage of education. In this paper, we present aspects of constructive learning which we inherit from developing mathability theory. We will investigate how to apply the methods to achieve scientific success (in learning, solving problems, gaining mental abilities, etc.) and personal success (discovering talents and potential, changing attitude towards problems, communicating, cooperation in a group, management, etc.).

Taking into consideration young generations' habits (among others: [2] [18] [21] [41] [46]) it is evident that they learn, work, and entertain using ICT. Moreover, they build their social life in a virtual world. Current demand of life-long learning and self-development is supported by technology. The methods we will discuss serve both using the habits as sufficient and effective tools of self-improvement and enabling people to meet the employers' demands. All the facts are strictly related to the definition of cognitive infocommunications (CogInfoCom; cf. [1] [3] [4] [5] [48]) and contribute to cognitive sciences by matching cognitive process in education with infocommunications devices and methods.

The paper consists of four parts. First, we present an evolution of the theory of mathability. We explain how the notion has broadened its range. In the second part, we describe some features of the contemporary labor market, requirements of employers and some problems related to that. In the main part, we propose a way of solving these problems by adapting constructive methods typical for mathability development: in the third part we discuss a notion of Learnability and in the last part – we prove applicability of mathability methods.

1 Evolution of the Concept of Mathability

By *mathability* we used to understand human mathematical ability. In 2013 P. Baranyi and A. Gilányi introduced a broader idea of the concept (cf. [3] [5]). Mathability began to refer to a branch of Cognitive Infocommunications that investigates any combination of artificial and natural cognitive capabilities relevant to mathematics. The range of the notion varies from low-level arithmetic operations to symbolic reasoning of a high-level.

Among others, there were two main goals considered:

- To develop a set of methodologies using which human mathematical capabilities can be emulated and enhanced.
- To work out a measure with which artificial mathematical capabilities can be quantified.

1.1 Emulating Human Capabilities

Since 2014 P. Biró and M. Csernoch have investigated students' ways of thinking while problem solving. Namely, they considered deep and surface metacognitive processes in non-traditional programming tasks, computer problem solving approaches and mathability of spreadsheet tools (read more in: [6] [7] [8] [27] [28]).

K. Bubno and V. L. Takács have considered application of word problem solving as initial computer programming exercises ([15]). They described usefulness of some methods originated from mathematical education to teaching computer science (16]). On the other hand, they presented how to solve mathematical problems using Blockly ([17]).

A. Gilányi and M. Merentes have investigated applicability of existing computer algebra systems for solving mathematical problems ([11] [12] [13] [33] [34]). They presented ways of getting ideas leading to discovering solutions of unsolved theoretical problems. In that way, they contributed to 'experimental mathematics'. Among others, they proposed computer aided methods of solving linear functional equations, and (together with R. Quintero) presented an animation related to a convex-like property ([35] [36]).

1.2 Quantification of Artificial Mathematical Capabilities

While developing the new notion of mathability, a need for introducing a quantification of artificial mathematical capabilities appeared (among others: [5] [18]). A simple calculator, a graphical calculator, a computer algebra system (operating with formal mathematical language) – require different skills from a person using the devices. Designating a particular measure of demanded mathematical abilities could simplify answers to some important questions, for instance such as:

- What sort of a smart device is allowed to be applied during an examination?
- Who and in which form should control whether the device does not exceed the admissible capabilities?
- What mathematical skills are required from a candidate for a given position?

Until now, no formal scale of quantification has been introduced. Nevertheless, we can say that a simple calculator has a low mathability level, while a graphical one has a higher level. Moreover, we can designate a high mathability level to devices on which it is possible to install any mathematical application. Thus, the higher mathability level of the application, the higher level of the device. In this sense any smartphone is of a high mathability level, since we can easily use an advanced application solving computational and formal science problems, for example in mathematics, physics, chemistry, statistics, etc.

As an example we can point out such applications as Photomath or Wolfram Alpha, which are popular among students of schools and universities. What is interesting, the two high mathability level applications can be successfully applied by users with a basic level of knowledge and understanding of the mentioned sciences. The applications are frequently overused for finding solutions instead of solving problems by the users on their own. It leads easily to unrecognized errors, making mistakes in concluding or building mental maps. Having the method of quantification of mathability it could be possible to warn users they are expected to operate on the appropriate level. Unfortunately, easy access to advanced, professional applications and devices causes that they are applied in learning by people who are not ready to understand results produced by the equipment. This is why the notion of mathability was naturally broadened to the educational aspect.

1.3 Educational Aspect of Mathability

Technological revolution brought various devices supporting problem solving such as, for instance, statistical inferences, complex calculations, deriving formulas. The devices provide also an aid for education, research and personal development. Taking into consideration young people's habits new teaching methods were developed and introduced. The aspects were investigated, among others, in [10] [19-22] [32] [44-47]. The authors proved meaningful changes in perceptive

templates of the young generation. On the other hand, several risks were described related to overusing smart technologies and internet sources of knowledge, applied with no reflection or when the knowledge is not sufficiently understood. An attention was also paid to the changing role of educators (see: [18] [22] [23]).

All above mentioned investigations show how the notion of mathability evolved and how its educational aspect was broadening. Starting with developing teaching and learning computer science with mathematical methods, we showed how to apply computers in mathematical education. Moreover, it was exemplified how to use computer assisted activating methods in teaching sciences and what constructive learning means in this context (read more in: [23] [30]). Finally, we discussed applicability of the methods for soft-skills training [18]. Currently we can talk not only about mathability in the sense of processing data (by programming or with human brain), building knowledge with formal algorithms, creating mental structure of knowledge but about ability of learning in a general sense, which may be called “Learnability”.

The deep need for possessing Learnability is drawn in the following chapter.

2 Contemporary Labor Market

2.1 Cognitive Infocommunications and Skills Demanded by the Labor Market

The technical revolution causes dynamic changeability of habits, lifestyle, and labor market. It is difficult to predict what sort of jobs will be offered in the future to graduates who are beginning their school education nowadays. Moreover, any employees must be aware of the need to change their profession in the future. The problem is traditional schools do not keep up with the changes and they require an instant adaptation. The generation gap between conservative teachers and modern young people results in demotivation for learning with traditional methods. What kind of knowledge and abilities ought to be offered by schools may be explained by the requirements of employers.

By the reports *Responsive and responsible leadership* (Davos 2017, 2019, https://www.weforum.org/focus/responsive-and-responsible-leadership), we can call the contemporary labor market as **anytime, anywhere**. Quite often, a job can be performed at a time chosen by an employee in a place in which they currently stay. It is observed that “smart” technology facilitates variety of processes and there is no company running its business without computers. There are super-structures created in organizations and they build new eco-systems of media, where social media are the most important ones. The social life and personal soft abilities are as important in the real as in the virtual world.

This is why employers expect new sorts of their employees' competences. Among others, we can point out:

- Accepting and being ready for changes
- Quick self-development
- Creativity and creative problem solving
- Critical thinking

The competences open the list of the most demanded professional skills of the future labor market. A short survey done among employers (cooperatives of Institute of Mathematics of Kazimierz Wielki University) shows that currently the list may be completed with:

- Effective interpersonal communication, negotiation
- Goal-oriented time and tasks management
- Human resources management
- Building teams and team cooperation
- Self-assertion and emotional intelligence
- Concluding and making decisions

The competences are taught to students of management and related majors, but they are demanded from any employees and candidates. It creates a need for a quick gaining of new knowledge and skills, popularly called soft skills. They mean a combination of interpersonal (human) skills and personal (career) attributes (read more in: [50]). It should be mentioned that the employers clearly state that hard knowledge of facts, algorithms, connotations, and hard (work related) skills currently play smaller role than soft skills. However, schools still put emphasis on teaching rather hard competences. Hence, the training of soft skills must be organized by the employees on their own, with support of employers, simultaneously with developing professional career.

Taking the above into consideration we can claim that not remembering but:

- Immediate selection
- Evaluation
- Data processing
- ICT aided making decisions

will become crucial human abilities aiding a process of quick gaining of knowledge and being the foundation of cognitive flexibility and readiness for changes.

2.2 Computer-aided Preparing to Professional Life

Described in the previous chapter, interpersonal skills and career attributes (known as soft skills) are the most important competences demanded by employers but not sufficiently trained at schools and universities. For example, according to the Polish law, a university curriculum must contain social or humanistic subjects providing competences, achieving which takes at least 5 ECTS points (i.e. between 125 and 150 hours of an average student's workload). It means that the majority of subjects are related to the professional knowledge considered by academics to be essential for becoming a specialist in the given branch of science.

The students' point of view is completely different. The following survey was done among 41 students of computer science (1st year) and mathematics (3rd year). Students come from 11 distant countries and study at two different universities in Bydgoszcz, Poland. Majority of them (95.7%) know clearly what they want to achieve in their private and professional life. 57.7% of the students declare they choose the major in order to possess skills sufficient to get any good job in their future. It means they expect to learn general competences, not necessarily specific for their planned profession. In fact, the job they plan to perform is not necessarily related to IT or mathematics. All students claim they achieve competences for their future job in informal education, attending certified courses or some internet courses (not ending with any certificates). Hence, we can conclude that academic education is not sufficient to let students prepare for their professions.

The thesis is also proved by results of a survey done by McKinsey Global Institute (MGB) published by J. Manyika in *Technology, jobs, and the future of work* (for details, we refer to https://www.mckinsey.com/featured-insights/employment-and-growth/technology-jobs-and-the-future-of-work). About 40% of interviewed employers (coming from 9 countries) declare that their employees do not possess required skills to perform their job well enough. 60% of respondents complain that candidates are not ready to deal with their professional obligations. 49% of employers observed that the job is not a challenge for their employees. An independent research was done in Industrial and Technological Park in Bydgoszcz, Poland. The answers given by employees clearly show that 70% of them do not have sufficient skills to do their daily routines. On the other hand, they feel their talent and personal competences are underutilized. It may mean they are employed on an improper position. This is why about 49% of them state that their job is not a challenge. Comparative results are presented in Figure 1. Blue bars refer to the international survey and the red ones – to the Polish research.

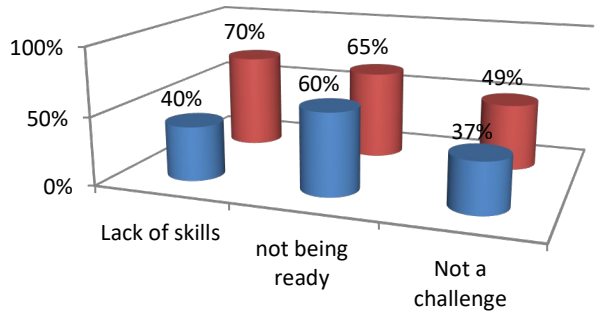


Figure 1
Employers and employee's opinion on readiness to perform a job

Now, it is worth investigating how young people get ready to meet the requirements of their current or future employers. From the survey done among students (mentioned above) we know that about 50% of them search in the internet for knowledge and competences deepening their interests but not related to the academic requirements, more than 38% of the examined students use internet to gain knowledge and skills deepening professional competences related to their current or future work. They usually use Google and YouTube to find professional advice. If they need a book they prefer pdf files (58.4%) and rarely borrow books from a library (15.3%). When browsing webpages, they frequently use positions from the very top of the list given by the browser (about 50%) and only 23% declare they read webpages advised by an authority. Taking into account that employees must deepen knowledge and skills in the process of a fast and adaptive education and self-education, the conclusion leads to the requirement of careful and deepened training of responsible ICT application in order to use internet and smart devices for self-improvement and development.

We should notice also that:

- Students finish or break their education at the bachelor level (for example, at Kazimierz Wielki University, on average, out of more than 90 graduates of computer science only 15 continue their studies)
- Some competences are taught by employers directly or indirectly by organizing proper courses and trainings
- The employees must learn while doing their duties

Concluding, future employees will continuously use multimedia devices to acquire knowledge, abilities, and even to build new relations. The dispersed and remote learning seems to be inevitable.

3 Learnability - Mathability for Education

Changeability and impossibility of predicting the future of the labor market offer as well as the requirements of a fast adaptive self-development of employees oblige the education system to prepare pupils and students to the responsible, conscious and useful life-long learning. It would be valuable to transform the system from traditional teaching to the computer aided constructive learning.

3.1 Cognitive Portrait of the Young Generation

A simple example presented in [20] (for further explanation, we refer to [41]) shows that the process of collecting and processing data is different for people trained in reading traditional (printed) texts and those who browse hypertexts.

Teenagers and university students are very good at essential reading of non-linear texts of webpages, searching for keywords and immediate matching, comparing and concluding. Unfortunately, solving problems or searching for new knowledge they are satisfied with sketchy solutions, they do not pay enough attention to deep understanding. They minimally reflect on the obtained result. Moreover, they use the easiest accessible sources of data. The most popular ones are Wikipedia and YouTube (more than 95% of respondents of the research mentioned above), and webpages chosen from the top of a browsing list (50% of respondent). 38% of the examined students relay on advised, specialist webpages. Among them professional courses on www.udemy.com are one of the most popular. Learners have a choice of multiple topics, information and methods. They limit their interests, knowledge and abilities to the preferable ones, not necessarily building complex mental structures.

All the above proves young people’s habit of superficiality and rapidly decreasing interest in formal education. For instance, our long term observation of students’ (aged 13-19) attitude towards learning mathematics showed declining interest in the subject, what is observed also at Polish universities (the number of candidates significantly decreases every year). Informal education plays more and more important role, and diplomas of higher education institutions lose their value. This is why the ability of efficient learning, Learnability, becomes more and more significant.

3.2 Foundation of Learnability

As we discussed above, as far as the education is concerned, teenagers and students are critical and lose their motivation for formalized forms of studies. Frequently, they do not learn what they are enforced to learn by the system of education, but what they need in order to build their consistent career plan.

Learners acquire knowledge and competences on the informal basis hence they learn what they consider important for them, and what, in their opinion, makes sense. Forced to learn what they find uninteresting or useless, they choose knowledge partially, incoherently; hence, the material is easily forgotten. Having a variety of offers on-line, they choose issues toward which they possess deep, inner motivation. They understand education as an investment into their future.

The described features are well known elements of learning patterns typical for adults (for details, we refer to [42] [43]). However, nowadays they are clearly observed already among teenagers. They demonstrate their interest in a few subjects and ignore other ones (bearing the consequences with bad marks).

What is a systemic answer to the changing requirements of pupils and students? Some solutions have already been proposed. For example, students of high schools are given a collection of subjects they can choose to learn on an advanced level (moreover, for instance in Polish high schools, not all subjects are obligatory). Projects and other activating methods are implemented more frequently to create an opportunity for learning a team cooperation, collecting data and applying knowledge, etc. Methods of selection, evaluation and ordering information are considered to be key competences and included in the school curriculum descriptions. Moreover, they are advised to be introduced already on the preliminary stage of a cognitive process. To obtain such goals we do need activating methods, engaging students, intensifying their motivation.

The reality seems to be far from those demands. Teachers declare knowledge of variety of activating methods. However, they apply them rarely since they are time consuming and do not engage the whole group of students (results of surveying educators, participants of workshops *Coaching in education,* conducted by K. Chmielewska during: nationwide conference *First of All Human. Bridges Instead of Walls*, Bydgoszcz, Poland 2019). The school curriculum consists of issues enabling students to collect (in the final test) a number of points which is sufficient to enter a school of the next level. The knowledge of definitions, facts, algorithms is still more important than soft and key skills mentioned above.

Additionally, among the known activating methods the educators did not mention *Problem Based Learning (*PBL) or *Inquiry Based Science Education* (IBSE**)** which fulfil all the requirements of modern constructive education.

Majority of the examined teachers declared also training of selection, evaluation, and ordering information. However, they were not able to point out such moments during their classes, when they regularly train these competences.

The conclusion seems to be obvious. The school and academic system needs to be transformed. It was also stressed in reports from the World Economic Forum Annual Meeting Davos 2020 (https://www.weforum.org/events/world-economic-forum-annual-meeting-2020/themes/society-future-of-work).

3.3 Constructive Learning as a Way for Achieving Learnability

To meet both requirements of the future labor market and demands of learners we propose a constructive learning method (which was described with details in [20]).

By constructive education we mean, briefly speaking, building knowledge and competences by experience. The idea precursors are J. Dewey ([31]), Gy. Pólya ([49]), J. Bruner ([14]) and J. Piaget ([48]). According to Dewey, school education should present real life problems and students should be given a chance to experiment.

Educational experiments (results of which are presented in [17-20]), and further investigation (discussed, among others, in [42] [43-47]) allowed us to observe a common cognitive pattern which can be explored as a method of conscious and responsible learning. In this method, assimilation of knowledge necessary for solving the given problem is represented by:

- Searching for the knowledge – a definition or broader description of the problem, examples illustrating the notions.
- Understanding notions, methods and examples.
- Following the way of the analyzed solutions.
- Finding an own solution of the original problem.
- Reflection and assessing the obtained result and applied methods.

Let us compare the method with Bloom's and Kolb's theories [9] [42] [43]). The method originating from the 50s and 70s, can be considered from a new point of view, taking into account the fact that young people learn like adults and, using smart devices and distant sources of knowledge, they construct their knowledge.

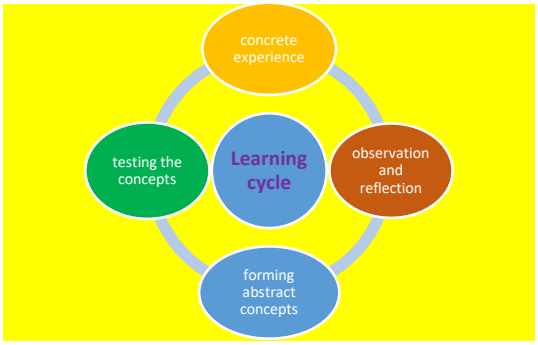


Figure 2
Kolb's experiential learning cycle

Students browse knowledge sources, search for information and examples

The step stands for Bloom's *stage of remembering*. In Kolb's cycle we could compare it to the stage of a *concrete experience*.

Since information is easily accessible, young people do not feel the need to memorize it. Instead of remembering, they find necessary information as often as they need it. It seems to be a strong habit of youth. Therefore, it should be trained to become a powerful tool of their self-improvement. For that, the next step is even more important.

Students evaluate and select appropriate information fitting the prior knowledge system

Two Bloom's stages are consistent with this step: *analyzing* and *comprehending*. It also corresponds to Kolb's *observation and reflection stage*.

It is extremely important to choose information which is understandable and credible. Skipping the step brings undesirable effects, for instance, building a false foundation for further investigation. Since it is a way of discovering, it is effective and has a great impact on durability of the possessed knowledge. Any mistake made that way will be hard to eliminate. It explains the fact why the skills of selection and evaluation must be trained at school even on the elementary level, since children absorb information collected from several sources, among which internet is the most common.

Students assimilate the new knowledge into the prior knowledge system

The step corresponds to Bloom's *applying* and Kolb's *testing the concept*.

Students compare, 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 input data. The new knowledge or skill becomes an applicable tool.

Students interpret new knowledge, which is adequate to Bloom's *synthesizing*

They have just gained new knowledge or experience. They search for further examples of usage. It is valuable to ask questions such as *what if*:

- We change one condition,
- We apply it for other input data.

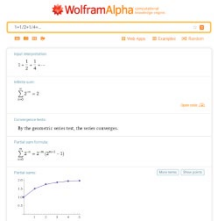
Students join pieces of information or part of a method together in order to create new meaning, structure or algorithm.

Students reflect on an overall result, evaluate new knowledge or methods

It corresponds to Bloom's *evaluating* stage.

The last two steps are adequate to Kolb's *forming abstract concepts* stage. 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. Students try to find out a new use of the result, broaden its usefulness, find its limitations, etc.

The described method of constructive learning goes beyond typical computer aided education, understood as a usage of internet sources of knowledge or applying popular educational applications (e.g., for Mathematics, Cabri, and Geogebra at schools, or Wolfram Mathematica, Statistica, MathLab, Mapple at universities). This is an applicable method of discovering, building definition, finding relations, recognizing properties, based, among others, on pupils' habit of using smart devices.



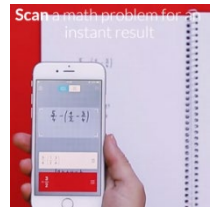


Figure 3
Tools aided constructive learning of Science

4 Applicability of Mathability Methods

Describing educational aspects of mathability we examined some activating methods and elements of constructive learning (see: [16]-[23] and [30] [38] [43]). Here we would like to discuss how the methods can be applied to general education, also for soft skills training.

4.1 Common Factors of Activating Methods

As Benjamin Franklin said: *Tell me and I forget, teach me and I may remember, involve me and I learn*, methods directly involving students into the process of education are much more effective and lasting.

It is worth mentioning some common factors of activating methods.

A change taking place in the students

Students, discovering knowledge and learning by experience, become more confident. They understand their right to make mistakes, not knowing is considered to be a natural state which provokes investigation. Doubts are reasons for asking questions and questions are natural tools of examiners. Instead of repeating: *I do not know since I am too weak*, they say *I do not know, so I will learn it. Let me try.*

Stable effects

As it was mentioned above, discovering and experiencing has a strong impact on learners thanks to the great effectiveness of the methods. Students memorize the material faster, remember what they have learned for a longer time, and understand it deeper.

Applicability for variety of problem solving

Among the steps of constructive learning there is broadening of usefulness of the created result. As a result, we mean not only what students obtained after a chemical experiment or mathematical computation but a way in which they gained their experience, as well. Hence, a method they have just applied for patient, diligent, dogged finding solutions may be applied for solving their life problems, such as planning their future, managing tasks, team co-operation, etc.

We may ask what the linking element is. The answer appears easy: **unconstrained engagement following deep and inner motivation, natural interest, and need of self-improvement**.

The methods described below are based precisely on the assumption that learners are deeply and internally motivated to obtain their goals, they take part in the process of education following their true interest and necessity.

4.2 Edu-Coaching

Coaching is a personalized and holistic approach, taking into account the fact that everyone is different and that our lives and development take place simultaneously in many areas. It is based on the relationship between coach and those coached.

Educational coaching (following a definition presented at www.coachingedukacyjny.edu.pl/#czym-jest-coaching) is an educational process aimed at developing competences of educators and achieving better learning outcomes by understanding children's behavior, skillful work with them and effective motivation to learn.

On the other hand, that is a process focused on improving and strengthening learning and development by increasing self-awareness and personal responsibility (for more details and examples we refer to [23] [37] [38]). A coach accompanies a student by asking questions, listening actively and challenging the student in a supportive and motivating way.

By J. Rogers ([51]) there are six fundamental conditions under which coaching must be conducted. We will explain how the conditions are fulfilled in education.

1) **A student owns necessary resources**

   Frequently students in a problematic situation resign from finding a solution, since they think the problem is too difficult or they are too weak to solve it.

The same students, motivated appropriately, reveal knowledge and competences sufficient to break their impasse, name the problem and find a solution which they can carry out on their own. Working with their coach they discover notions, facts, algorithm necessary to obtain their goals. A student's resource can also be the awareness of the right to lack knowledge and considering having a problem as a natural state.

2) **A teacher (coach) asks questions so that the student begins to use their resources**

   By asking questions the teacher (coach) creates a space for the student to think out all necessary answers. The questions do not suggest any answer. They only encourage and inspire to examine the problem from a different point of view or in relation to the student's previous experience. They may lead to a conclusion what is the missing part of knowledge, completing which will guarantee a success.

3) **Coaching refers to the past, present and future of the coachee**

   The past in the context of education means the prior knowledge and experience of the student, his previous habits and talents. The present refers to the current abilities and possibilities helpful for obtaining the desired objective. The coach accompanies the student while analyzing the sources. Moreover, the coach helps to reveal what is a real obstacle in breaking the problem. It enables the student to start working on his motivation, patience, creativity, and other personal abilities.

4) **The topic is chosen by the student**

   The student explains the teacher what the topic of the current work is, what the challenge is. The coach cannot insist on choosing another subject. Frequently, the student finds out the reason of the problem and decides to change the topic, but every time it is the decision of the student. The topic may be either a subject-oriented task or a personal ability which the student wants to improve.

5) **The student and the teacher are partners**

   During the coaching process the student and the teacher play role of partners. This is what distinguishes the method from mentoring and tutoring, where the teacher is a master, more experienced colleague or an expert.

6) **The goal of the cooperation is solving a problem or a change**

   Depending on the topic chosen by the student, the couple coach/coachee works on solving the problem or the student's personal **change**.

Solving problems or breaking impasse, in fact is a sort of defining a challenge which motivates the student for deepened engagement. In this case we talk about **transactive coaching.** It is a perfect way to support constructive learning in which

the student, answering questions, builds knowledge and gains skills. It is also a kind of support for learning through ICT aided discovering. The coach will take care to make the student avoid risks related to superficiality, lack of reflection and others we described above (more about risk of un-guided self-education one can find in [17] and [20]).

The change is related to obtaining and strengthening personal abilities. This is the case of **transformative coaching**. It is significant for strengthening motivation, discovering one's own capabilities, advantages and skills, abandoning limiting beliefs, revealing or improving talents, awaking self-confidence, etc.

Apart from the above application, coaching can be useful to improve interpersonal communication between:

- The teacher and the student
- The teacher and the student's parents

There are only two basic tools necessary to apply coaching in education. One of them is asking open and non-suggestive questions. It demands giving the student time to response. Even if the student is silent, the coach should not interrupt or answer instead of the coachee. Simultaneously, the student should feel free to take the time and not to answer immediately. The situation requires a deep trust and strong, partnership relation between the coach and coachee.

The other tool is known as, active listening. It means listening to words, emotions, attitudes, and behaviors, which requires the coach to focus totally on the student. Questions asked by the coach must follow what was heard from the student. The difficulty of the meeting consists in the fact that it cannot be planned and the coach must react on the spot to each student's message.

Since coaching is strictly formalized (e.g. the coach should not suggest any solution, nor give advice) other methods are more popular and more frequently used at schools. However, coaching in its pure form, is the most effective method of personal development thanks to the fact that the total responsibility belongs to the coachee. Other methods, for example tutoring and mentoring, share responsibility between the student and the teacher. Thanks to possibility of giving advice they might seem to be faster, i.e. the student achieves goals earlier or with less workload, but the effect may be less lasting.

Interesting and valuable results on Edu-coaching methods in 3D VR environments can be found in [39].

4.3 Tutoring

Tutoring, similar to coaching, is a holistic approach based on the relationship between a tutor with a tutee. The tutor is a facilitator of the development process the goal of which is **discovering talents and developing the skills of independent thinking and creation.**

The method is based on the principle of “Personalism” where a person is treated with awareness that they have their values, past experiences and plans and they need to be taken into account when conducting training. The tutor, as an expert in their branch, leads their tutee to the success asking inspiring and provoking questions. If necessary, the tutor can advise or suggest, can propose literature or directions of development. After each meeting the tutee is given a topic of an essay to write, in which they present their thoughts and justification of their personal ideas.

Again, we can distinguish two kinds of methods: focused on discovering and developing talents (developmental tutoring) or focused on developing knowledge in a chosen area (scientific tutoring). In the second case, the tutor must be an expert in the area of training.

The basic tools and methods applied in coaching are useful for tutoring, as well. The master asks open questions following the tutee argumentation, their needs and problems. The tutor listens actively to the tutee, reacting immediately to their talk, emotions, and behavior, challenges the tutee and proposes steps of their development.

Both coaching and tutoring are applied to the best students, who are ready to accept what they may reveal during the process. The methods are awards for the students’ prior achievement. The methods described below are appropriate for any students and pupils.

4.4 Soft Skills Training

As we wrote in chapter 2 (following [50]), soft skills mean a combination of interpersonal (human) skills and personal (career) attributes. From own experience and interviews with some coaches and business trainers we can claim that among the most popular skills chosen by clients to be trained the following ones can be listed:

- Team cooperation
- Team building
- Team management
- Time and task management
- Emotional intelligence
- Negotiation
- Communication
- Assertiveness
- Personal and team effectiveness (which are composed of some of the above skills on this list)

The above skills coincide with all of the needs of the labor market and demands of students completing their education before starting their jobs (as described in Chapter 2).

A trainer of soft skills uses coaching methods of asking inspiring and provoking question, but at the same time presents the theory necessary for understanding processes of management, communications, etc. A great and difficult ability of the trainer is to build a training on the spot, following a situation created at the given moment or responding to particular trainee's needs. The trainer must be able to manage emotions of the trainee or of the whole group of participants.

The described method is called a "Consultment" training. It is more efficient than any course presenting methods and giving instructions in a stiff way, where examples are prepared in advance without examining participants expectation. During consultment training, the examples and exercises are being composed at once, according to the current need of participants. The method is interactive and follows the action of the group and each individual participant.

Like previously described methods, soft skills training is a holistic, but group process, which means that not only a single trainee but the whole group will evolve and change during the process. Being aware of the stages of the group process, an educator may manage the development of the class as a group or a students' group as a team, simultaneously with teaching them the subject material.

4.5 Networking

By networking we mean the exchange of information and ideas among people with a common profession or special interest, usually in an informal social setting. Objectives of networking include, among others, expanding circles of acquaintances of participants, finding out ideas about job opportunities in their fields, and increasing their awareness of news and trends in their fields or in the greater world.

It is performed, for instance, as trade shows, seminars, and conferences, which are designed to attract a large crowd of like-minded individuals (more details may be found at www.investopedia.com).

Let us present a Polish example of after school extracurricular education, which includes also networking as a method of exchanging ideas (details may be found at www.kopernik.org.pl/en/projekty-specjalne/).

The project is coordinated by Copernicus Science Centre in Warsaw, Poland. Up till now, it has involved more than 500 Polish schools and universities into an active cooperation. Kazimierz Wielki University in Bydgoszcz as a partner in the project will examine the effectiveness of the constructive education.

Pupils and students are inspired to observe, experiment, ask questions, and seek answers in biology, physics, chemistry, mathematics, and other sciences. The applied methods change the common teaching to the system of constructive learning. Unfortunately, since students choose the topic of each meeting it is hard to predict objectives which will be achieved. Because of that the method cannot be applied on the regular basis, since the formal education system requires to plan in advance a list of learning outcomes. That is not possible in the project. The only objectives planned to be achieved are soft skills such as, for instance, asking questions, effective communication, team cooperation, self-motivation, adequate self-esteem, deepening self-confidence, etc. What students will learn depends on their interest, but they definitely will obtain personal abilities useful in their life and professional career.

Conclusions

Perception and learning practices are strongly influenced by the habits of using multimedia, smart devices and the tools of cognitive Infocommunication. The system of education needs to be transformed, since modern education should take advantage of new habits, in order to help students to be ready for life-long learning and to find a satisfying position in a dynamically changing labor market. Teachers, in the new formal system, should play the role of facilitators, mentors or tutors to assist pupils and students, in gathering information, making conclusions, discovering, and solving problems.

Students may apply high level Mathability devices and applications, as well as, use multimedia knowledge sources, however, they must be guided by the facilitators in order to avoid risks of superficiality and building inadequate knowledge structures.

Acknowledgement

This work was supported by Kazimierz Wielki University in Bydgoszcz.

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