Computer Assisted Activating Methods in Education

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***Abstract*—Mathability, according to its definition, combines machine and human cognitive capabilities essential for mathematics. However, the notion can be extended to methods of processing information in a structural way in consideration with any science. In this paper, we describe the need of constructive learning aided with smart devices. The brief characteristic of Millennials is presented and some forecasted changes of the labor marked are outlined. Finally, an example of constructive learning is given.**

***Keywords*—Mathability; Education; Constructive Learning; Key Competences; Activating Methods; Tutoring.**

Introduction

Considering perceptive templates of the 'young generation' (people born between 1995 and 2012) it is worthwhile to investigate new learning methods aided with devices equipped with adequate applications supporting a process of making decisions, statistical inferences, complex calculations, deriving formulas, etc. Following the youth habits of overusing ICT tools in their everyday live it is necessary to apply constructive educational methods which motivate learners and change their attitude toward education. It is also useful to take into consideration a general characteristic of at least two generations (Y and Z) and their influence on the youngest generation, currently going to schools. For those students we would like to propose some activating teaching methods aided with ICT tools which will be useful for their life-long learning strategies, their education and future professional life. Economic reports demonstrate that except of proficiency at using ICT the future employees should have some important soft skills.

Problems and questions related to the education of the young generation were investigated (generally and from various points of view) by several authors. They considered, among others, digital competences, multi-tasking, rapid decision-making, finding connections and the generation gap between teachers and students (cf. [42], [15], [28], [31], [37], furthermore, [19], [25] and [26]). General studies on computer assisted education were also performed in several recent papers (e.g., in [8], [29], [30], [36] [39], [41]).

Our aim to investigate some connections between the characteristic of students and mathability. Mathability, as a branch of cognitive infocommunications (CogInfoCom) (cf. [2], [1], [3] and [5]), refers to combinations of artificial and natural cognitive capabilities relevant to mathematics ([4]). Its relation to human factors and its educational aspects were studied in several papers (cf., e.g., [6], [7], [14], [11], [12], [13], [16], [17], [18], [35] and [43]). For information about its connection to computer assisted solution of mathematical problems we refer to [9], [10], (cf. also [23], [24]), [21] and [22].

In this paper, we point out a need of transforming the system of teaching to a system of creative learning and we propose some activating methods originated from mathability.

I. Generations of Millennials

Generation Y (born in 1980-1989) is the first generation of Millennials. They have been stating their activities on the labor market. They turn out to be multi-tasking and open to new challenges. They are engaged in their work if they find it interesting. They appreciate flexibility of time and place of work. They expect satisfying salary and require a broad support of their professional development. They distinguish authority and position. They define authority as having high level competences. Hence a person with a broad knowledge and great practical experience on a parallel position will stand for an authority more than any supervisor or manager without such competences. Therefore, they expect sharing responsibility, close relation in their team and being opened for discussions. On the other hand they have some unrealistic expectations, act for their comfort before they work for the employer's benefit [44].

Generation Z (born from 1990) is called also generation C for the three typical characters: connected (to Internet), communicative, ready for change. That is the youngest generation on the labor market. They do not remember the time before the Internet. They are open to new creative solutions. They live simultaneously in two worlds: real and virtual, admiring both closed real friends and virtual social media friends.

However, generation C has a problem with concentration, with staying long in one place. It refers to their everyday life as well as to their vocational habits. They like to build their career changing employers and firms whenever it is favorable to them. They usually do the analysis superficially (see also

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[11], [12], [13]) and assess hastily. Although they are uncertain of their future they live their dreams which motivate them and give a power to achieve their goals.

The younger generation growing up, which is still learning at schools, can be formed by their educators, even if the young people are influenced by older familiars. We can neither stop the technology revolution nor prohibit teenagers to use the revolution products. We can only teach them how to do it in order to benefit in their private and professional life. The general characteristic of the next generation depends on our attitude towards its education. There are still some elements missing in the school education that we should pay a lot of attention to: balance between real and virtual world, patience and persistence, searching in variety of sources, selection and evaluation of information. These abilities will enable the pupils to use technology for their successful education and profession, and for their healthy entertainment.

It should be noticed that perceptive abilities of the youth have being transformed because of the multiplicity and free access to information, variety of devices supplying the information and supporting its processing. In [12], we characterized some elements of the youth's cognitive patterns. It is worthwhile to recall some of them:

- Fast essential reading. The young people's skills are, among the others, searching for keywords and immediate matching, comparing and concluding. They demonstrate higher efficiency of reading than their older colleagues since the process of transforming data is more effective for those who explore hypertexts than for people trained in reading printed texts (cf. [13]; for more details, we refer to [31]. However, in [13] we proved how misleading it is to read keywords when they fit the students' prior knowledge systems. Students are satisfied with a sketchy solution. They neither understand the core of the problem and its solution nor reflect on the result obtained.
- Superficiality. The majority of students uses the easiest accessible sources of data, e.g. short and simple Wikipedia explanation. They apply the knowledge given there, which in fact is only an introduction to the detailed description. Hence they do not explore the essence of the required algorithms, methods and contents. A disadvantage of such a habit is the students remember mostly the part of knowledge they discovered on their own even if they are given more detailed and advanced information and explanations (read more in [13]).

Summarising, what should be trained at schools to provide the pupils tools for effective education are efficient searching for keywords, persistence in order not to be contented with sketchy solutions, concluding and correct matching new knowledge with a prior knowledge system, applying smart devices to support necessary calculus, inference, etc.

To complete the characterization we should notice that pupils nowadays can choose between multiple information, topics, methods, offers. They learn soon how to recognize their favourite contents and activities. They limit they interest, information, abilities to the preferable ones. Hence, we can observe elements of learning patterns typical for adults in the teenagers educational templates ([27]).

Among the other features of the education of adults, which can be observed in teenagers behavior, we may list:

- choosing the material which they are interested in, limiting their interest, teenagers are critical and do not learn what they are enforced to learn by the system of education,
- pupils collect knowledge on the informal basis hence they learn what they want, what is important for them,
- they learn uninteresting things reluctantly, learn rather the things which in their opinion make sense; if they are enforced to learn, they choose knowledge partially, incoherently, hence the material is easily forgotten,
- the youth is not motivated to study material they are not interested in, they are assertive and stubborn.

In response of these features pupils are given a collection of subjects to choose (e.g., in high schools in several countries, not all subject are obligatory). Moreover, projects and other activating methods are more and more popular, however, since they are time consuming, they are not applied frequently enough, even if they are much more effective.

Following [27], it is necessary to teach how to select, evaluate, and order information, as soon as possible, on the preliminary stage of a cognitive process. Additionally, we can observe a kind of confusion experienced by the pupils (even older onces). It is caused mainly by peer groups and mass media.

II. Necessary Changes

The best progress in learning could be observed if pupils would share responsibility for their education. Moreover, the youngest generation in their early years should be equipped with soft skills necessary for their future life-long learning education and professional work, since education must keep pace with dynamical changes of the labor market.

Let us quote some remarks of the report of annual meeting of World Economic Forum (WEF) in Davos, 2017 (see: `https://www.weforum.org`) In the report 'Responsive and Responsible Leadership' the character of the labor market was called 'anytime, anywhere'. New technologies allow to work exactly anytime and anywhere. They cause also changes of conditions of work. 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.

The changes cause a need for training new competences of employees. Among the most important ones, there are 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.

The list of demanded soft skills can be completed with:

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

(Cf. 'Uczmy się jak maszyny, a nawet bardziej' written by the Head of Services Central and Eastern Europe (CEE), Microsoft, Norbert Biedrzycki and published by Forbes in June 2019; also available at `https://www.forbes.pl/opinie/uczmy-sie-jak-maszyny-a-nawet-bardziej/dpzl0gr`)

We can predict that the 'hard knowledge' may loose its value. Students will be soon convinced to learn continually to ensure possessing a stable employment. Immediate selection, evaluation, data processing and ICT aided decision-making may become crucial human abilities instead of remembering. This is why mathability methods (see: [11], [13] and the chapter below) will be widely applicable in any field of education.

Namely, let us point out the areas of computer aided support in the process of preparing pupils and students to their professional life [27].

1. Communication skills, intercultural competences, readiness to remote and virtual work are forecasted to be be one of the most required features of the employees. They will be obliged to learn permanently, independently from their positions. Careful and deepened training of responsible ICT application for the time of school education can ensure current student they will cope with this challenge.
2. Pupils and students, when they grow up, will acquire new skill and knowledge through their whole life. This has been already observed that Millennials build their CV step by step changing their job and employers as often as necessary. So will be the next generation's feature. Hence it will be necessary to diversify knowledge. That shows keeping 'stiff' knowledge in our mind will be less valuable than selecting it and processing immediately. Requirements of the labor market have been changing rapidly. Classical educational systems are not able to keep them up in many countries. According to [38], in nine countries, 40% of employers claimed lack of appropriate abilities and it had been the main reason for free work places. 60% of them claimed that new graduates had not been ready enough to start their professional life. Moreover, a research conducted via LinkedIn portal showed that 37% respondents complained they do not use their competences and their professional obligations are no positive challenge for them. Those people will certainly deepen their knowledge and skills in the process of a fast and adaptive education and self-education. Such methods of collecting knowledge and achieving abilities must be supported with smart devices, also with a high mathability level.
3. The educational system needs to be transformed. Nowadays, lots of students finish or break their education at the bachelor level. Some competences are taught by employers directly or indirectly by organizing proper courses. The employees must learn while doing their duties. It is why the educational aspects of mathability and the ways of achieving learnability described in [11] and [12] are so important for the young generation.
4. The future employees will continuously use multimedia devices to get the knowledge, abilities, tips, build new relations. The dispersed learning seems to be inevitable. Hence it is an obligation of the education to prepare pupils and students to the responsible, conscious and useful lifelong learning.

Such conclusions imply a necessary requirement that teachers consciously provide pupils conditions to experience responsibility and consciousness for learning materials that pupils find important, significant or applicable for their vocational career. In other words, it is recommended to build a system of constructive education, i.e. learning by building knowledge, discovering, problem solving and critical thinking.

III. Proposed Solutions

A. Experience it. Feel it.

The model of learning described above is based on the observation that nowadays pupils and students learn partially like adults. Hence in their education we should use some methods appropriate for adults. Among them we can recall Kolb's learning cycle [33], [34] (cf. Figure 1). Kolb's model is also called an Experiential Learning Model. It describes a way in which it is possible to convert our experience into the knowledge and changes of behavior. It is based on the achievements of John Dewey, Jean Piaget, Kurt Lewin, William James and Carl Gustav Jung (cf., e.g., [32], [20] and [40]).

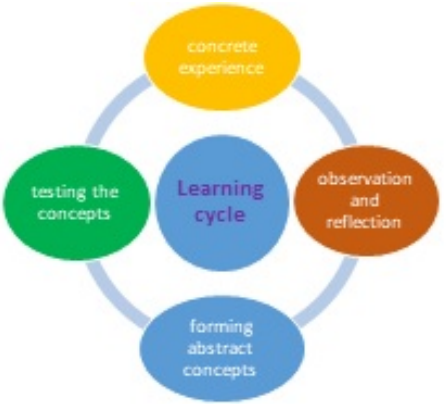

Figure 1
Kolb's learning cycle

In [12], we presented foundation of constructive education and explained how the Kolb's cycle can be useful for creating a taxonomy of learning outcomes of this kind of education. The idea of progressive education adjusted a personal path of learning for each of four styles of learners: converger (being good at practical application of ideas), diverger (generating ideas), assimilator (creating theoretical models), skillful accommodator (solving problems intuitively). Here, we would like to pay attention to the case of starting the cycle with a concrete experiment. Such a choice is excused by the way the young generation collects information and assimilate it. It is necessary to notice that the method improves not only knowledge and scientific skills but social abilities as well.

We can consider a case of problem solving in mathematics, physics or other science. Pupils or students start learning with involvement in an experience. Using smart devices, they collect information and select it. They invoke also their previous knowledge and experience. This engagement evokes feelings and arouse emotions making the process more effective. Next, there is the time for reflective observation or pure reflection. A teacher playing a role of a facilitator can ask questions. For instance:

– for science: What have you discovered? How can you define the problem/notion? What have you observed?
– for social skills: How have you felt? What have you liked? What haven't you liked? How have you managed to solve it? What (which of your features) has helped you?

Next step is to conclude and make abstract concepts. Examples of questions can be as follow:

– for science: How can you summarize it? What is the conclusion? How do you understand it? What does it imply?
– for social skills: How to use it to another problem solving? To which one? What was wrong (did not work as you expected)? How will you do it next time? What have you learnt about yourself?

Having the concept students can build an algorithm or a plan of a universal solution and train it with a variety of examples. The teacher can continue with questioning:

– for science: How to apply the method? What improvements could you introduce? What could be the next step in development of the procedure?
– for social skills: How can you evolve your success strategy? Where can you use the strategy? What difficulties have you broken? What have you used to break it? Who helped you?

Above questioning gives us some example of open questions broadening pupils' and students' mind, presenting them a new perspective, letting them to build knowledge by creation. A person facilitating such a process does not give information and let the learners be independent. Assessment is traditional but take a form of a feedback pointing out what was well and what needs to be improved. The method is used by tutors, however it is applied usually to work with the best students. Taking into consideration that the most demanded abilities on the labor market are innovation, creation, creativity, communication, readiness for changes we ought to use tutoring with much bigger group of pupils and students. Tutoring, working with questioning, social abilities training as frequent methods in the school education may help to meet the challenge. Technology can be (and frequently it has already been) an ally in students' learning.

B. Extracullicular and after-school education activities

We would like to present an example of a project which stands for an answer to the need widely characterized above. The project is coordinated by Copernicus Science Centre in Warsaw, Poland. The Center cooperates with more than 500 schools in whole Poland and with several universities. This year Kazimierz Wielki University in Bydgoszcz has become a partner in the project in order to extend the network of schools in the Kujavia and Pomerania region as well as to start examining the effectiveness of the constructive education fulfilling all conditions mentioned above in the paper. By the project pupils and students are inspired to observe, experiment, ask questions and seek answers in biology, physics, chemistry, mathematics, and other sciences. The methods applied change the popular school system of teaching to the system of constructive learning. Namely, students experience knowledge and train skills by:

– experiments and inquiry-based learning (IBL, IBSE),
– problem solving (PBL),
– creating and constructing,
– networking.

The project authors' aim is to break a 'style succession', i.e. to stop repeating the system learnt by new teachers from their own teachers at their schools. Teachers involved in the

project form small groups of students working after regular classes without a time limit of a single lesson. Children are trained to recognize uncertainty and lack of knowledge as a natural situation and a necessary condition for discovering and development.

IV. Conclusions

Perception and learning practices are strongly influenced by habits of using multimedia, smart devices and tools of cognitive infocommunication. Teachers can play a role of facilitators, mentors or tutors to assist pupils and students to gather information, make conclusions, discover, solve problems. The ways of the young generation's cognition and knowledge assimilation have been modified. Modern mathematical, technical and science education should fit the new habits in order to help the students to be ready for life-long learning and getting a satisfying position on the dynamically changing labor market. Applying high level mathability devices and applications as well as using multimedia knowledge sources, guided by a new sort of teachers facilitating learning can be very helpful. Thanks to transforming the system of teaching into a system of learning such wrong habits of the young people as lack of accuracy, sketchy solutions, lack of assessment and reflection, can be easily eliminated and replaced by selection, evaluation, concluding, critical thinking, in short – by conscious and responsible development.

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