THE NEW PARADIGMS IN EDUCATION AND SUPPORT OF CRITICAL THINKING WITH ARTIFICIAL INTELLIGENCE (AI) TOOLS

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ABSTRACT. The growing abundance of information in all spheres of public life, stemming from the rapid take-up of new information and communication technologies, poses new challenges for the development of mankind. The study examines this phenomenon in the field of education, as education has particular importance and complex influence on the whole human life and careers. The need to establish, from an early age, some sort of "filters" in the consciousness of students to help them sift the really important things in the ocean of information and develop their knowledge in a consistent and balanced way, building on sustained learning, is key to their harmonious development as citizens and professionals, regardless of their profession. At the same time, for logical reasons, the increasingly sophisticated systems of AI can and should find an adequate implementation in education, assisting this essential process of filtering and promoting the so-called critical thinking among adolescents.

1. Introduction. For centuries, knowledge has been transferred in a certain sequence – from teacher to student, in a kind of copy-paste mode where rarely anyone dared to object or challenge the reputation or knowledge of his

teacher. True, globally it has been constantly upgraded and enriched, but in different epochs it has developed at different speeds, and its movement has not always been elevated, and sometimes different political or religious doctrines have proved to be a major obstacle to the harmonious development of human progress. According to Kuhn [6], science is not a well-regulated activity where each generation automatically builds upon the results achieved by earlier workers. It is a process of varying tension in which tranquil periods characterised by steady accretion of knowledge are separated by crises which can lead to upheaval within subject disciplines and breaks in continuity.

In the illustration below (Fig. 1), we can see an abstract pattern of accumulation of knowledge and skills in a given subject area over time. There is no way to find out how many times and in how many areas such "delays" in knowledge development have happened in ancient times, but there is a rational and empirical evidence from a newer age that when someone, far ahead of his time, has tried to push a revolutionary theory, it has been challenged and attacked by any means from the respective rulling class, as they perceived it as a threat to the status quo.
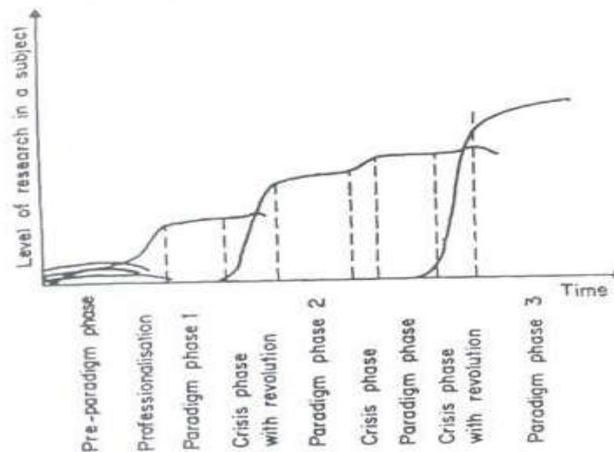
Fig. 1. Graphical interpretation of Kuhn's theory of development of Science
(after Henriksen, 1973)

In a number of cases, science has been literally stuck before someone dared to show that the foundation that lay beneath was wrong. For instance, for thousands of years, people thought the Earth was flat and it was not easy to be convinced otherwise. It was not until the Middle Ages that the scientist Nicolaus Copernicus, with his heliocentric system, proved another fact commonly known today, namely that the Earth revolves around the Sun and

not the other way around. Opposition to the centuries-old dogma has led to violent resistance on behalf of the official church, and about a century later the Italian Giordano Bruno was burned at the stake for developing further Copernicus's theory and daring to endanger the authority of the religion that at that time was still the foundation of the state power and his ideas were perceived as a direct attack on the existing public order.

In the rapidly rising knowledge economy since the end of the last century and the beginning of this one, the traditional knowledge model, based on the constant accumulation and upgrading, has dramatically changed. If we use an allegory from the construction or architecture business, as buildings can be upgraded to a certain level without collapse of the supporting structure, so scientific knowledge can develop to a certain extent until it turns out that the accumulated empirical facts no longer can be explained by the existing theories. Normally, then, the cognitive breakthrough shows up, and the whole scientific construction has to be demolished and rebuilt so that it can already take over and explain the controversies.

The Internet Era is characterized by information abundance, unknown in all the previous centuries of human history. It is enough to reach out a hand, and Google, Facebook or CNN flood us with information from all areas of knowledge, as factology itself is no longer a monopoly of anyone. The facts reach first the people with the fastest internet or best keyboard and mouse skills, and the contradictions with existing theories show up much quicker as our comparability basis increases thousandfold.

Logically, this dynamics of new information accumulation should be mastered in some way, and here comes the potential of critical thinking. Naturally, these opportunities can not arise on bare ground, and so the role of education in generating such a mechanism of rational and argumentative sifting of "significant" data into the student's mind becomes obvious. Such an impact can be greatly enhanced by the opportunities provided by artificial intelligence technologies, especially in big data processing, as the learner can in real time assess the effect of one or another assumption, and there is no the need to rely solely on his instincts.

2. Differentiated approach and personalized learning – foundations of educational transformation. We all wear different clothes that fit our sizes, shapes, and preferences, while at the same time we somehow accept as normal for all children to study the same things, in the same way. The paradox is that all the time we are fully aware that these are different people and their brains perceive things strictly individually. Obviously, it is high

time to realize that the world is changing dramatically, and there is no longer any excuse for us to justify that learning process continuing on the conveyor model that was characteristic for the industrial age, because we didn't have any other one in order to compare. There are already thousands of online educational providers running various learning management systems (LMS) nowadays that compete or complement each other. Moreover, as seen on Fig. 2 the suppliers of the various LMS modules may not be the same – the idea of open standards in the long run will inevitably lead to the concept of a distributed knowledge management system which, on a modular basis, takes the most cost- and technology-effective solutions from different large providers and offers them as an integrated service [9].
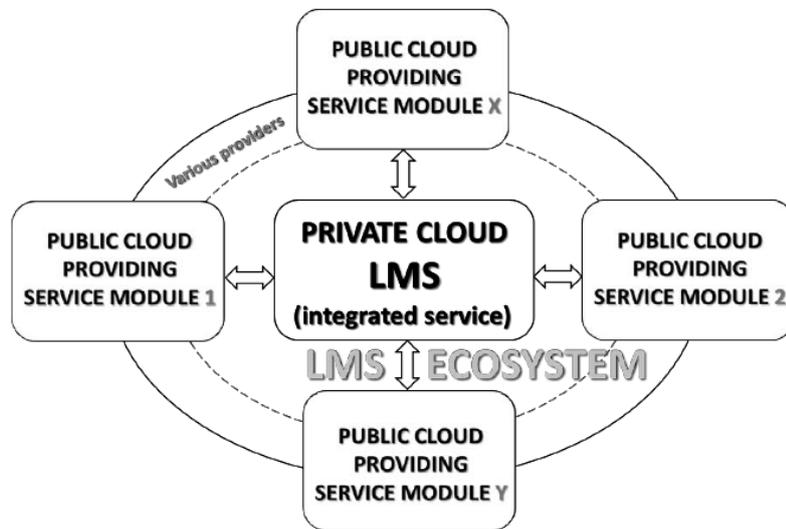
Fig. 2. Development of LMS as a federation of available public cloud services

In fact, differences in individuals' thinking, perceptions, and sensitivity are often far more significant than physical differences, and in this aspect we must realize clearly that *all children are concrete personalities.* Consequently, there is no logic in learning the same things beyond what is absolutely necessary, which is not very much, so it is enough to consider what percentage of what we used to learn in school or university has remained in our minds after 20–30 years of professional realization. True, the information that is available to us grows exponentially with every day and hour. However, the essential elements of it, which can directly influence our existence and future, do not follow the same dynamics and there is no need to make proportionate processing efforts every time we encounter the information avalanche. In the following figure (Fig. 3) we

can see that unless something is truly important for us and we review it on a regular basis, it is unlikely that we'll remember it after week or a month, not to mention years.

It is enough just to learn as early as possible to evaluate and sift the truly important things and that is where technology can already be of major help to us.
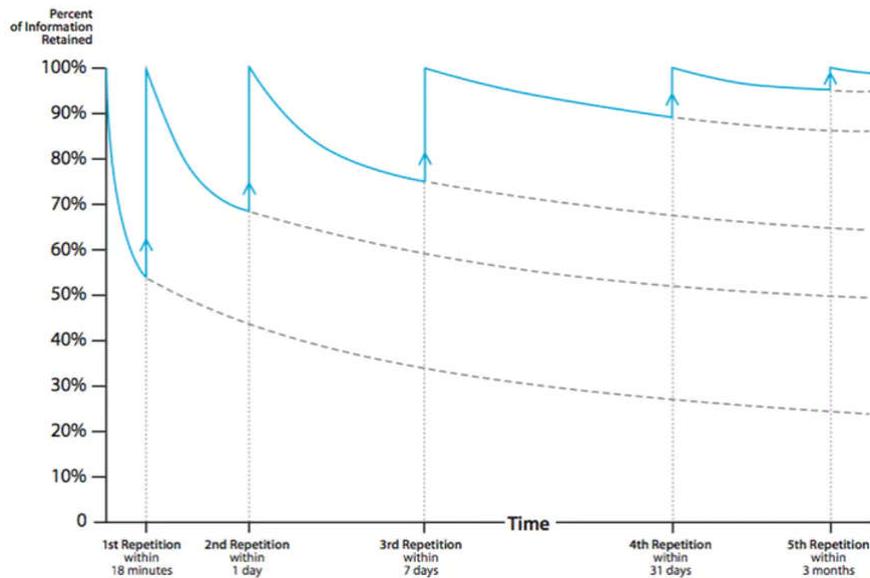
Fig. 3. Essential data and the need to revise in the information age [2]

We can talk a lot about learning at various speeds, but in essence it is simply a denial of the "equalizing" that has governed the educational process for centuries. We have already mentioned that learners are different, as are their capabilities, interests and perceptions. Equally different is their potential for development in one or another educational or scientific field, and by passing them through the filter of "equality" that was typical for the most classical educational systems, we lose the essence of their individuality, creativity and interests. Again and again, we make the same mistake by subordinating the education of students to a socially acceptable vision of "the necessary sufficiency" of knowledge, which often turns out to be inadequate to both the needs and opportunities for their future development and personal prosperity. The paradox in this case is that by pretending to defend the "community good" in the field of education, we actually deprive our children of an adequate future, and society of an innovative thinking and prosperous development. Over the time, the need

for revolutionary change in this educational stereotype has become increasingly pressing.

Of course, in practice, it is not easy for a teacher to allocate enough time for individual work with each student, but in this aspect, the new technologies and artificial intelligence can be extremely helpful, providing a modern educational toolbox that can change the quality of the learning process. New ICT provide opportunities for:

- Selection and recommendation of information;
- Context-dependent use of digital resources;
- Analysis, understanding and interpretation of the content, etc. [8].

3. Information, knowledge, creativity and critical thinking.

It is not important to know much, it is important to know enough and that is the essential difference between information and knowledge – *in essence, knowledge is a type of an organized information that gives you opportunity to achieve a specific measurable goal.* In the 21st century, when information floods us daily and everywhere, obviously the need for a flexible filtering of the really important things is a key competence for every individual, and in this aspect, the critical thinking is invaluable. It helps us not to serve blindly the authorities and just follow premade templates, but to be real innovators in our day-to-day activities, taking dozens of decisions that are not based on routine but on sound logic and adaptive thinking in order to keep at the top of the information avalanche. Changes are everywhere – from traffic jams, to turmoils in political news or social life that a terrorist attack could influence in hours or to financial markets that can collapse in minutes. All this requires rational judgment, adaptive logic, and critical thinking, so the true leaders of the modern society are usually among the people who have best mastered these life lessons, one of the most important being not to accept a thesis as undeniable without an adequate evidence. We must learn this critical view of life from a very early age, as the emergence of genuine innovation usually accompanies the people with critical thinking. Gamification, for instance is among the major engines for stimulating students' motivation and their interest in critical perception of the surrounding environment. Serious games can play an important role in modern-day education by combining appropriate content with interactivity and they reflect both the current state of technology and the learners' social profiles [7].

Nowadays, the countries more advanced in education, as a rule, encourage critical thinking and debate in lecture audiences, precisely because of the high competitiveness of the cognitive process and the quality of education. The most respected teachers, therefore, are no longer the ones who know the

most, but those who are most inclined to jump over the barrier towards the students and to embark on a process of discovery together with them, motivating them to new heights in knowledge. Or, as the researcher Anisa Zulfiqar says in one of her articles, "Critical thinking is not just a 'nice to have' skill in the 21st century, it is essential ..." [17].

The critical thinking means dissatisfaction with the status quo and usually accompanies creativity, which turns out to be no less important than the knowledge for the individual's success, so we should not be afraid to defend our standpoint, no matter what authority we are facing. As the world-known educational researcher Sir Ken Robinson says in his most popular TED Forum speech [12] "Now, I don't mean to say that being wrong is the same thing as being creative. What we do know is, if you're not prepared to be wrong, you'll never come up with anything original – if you're not prepared to be wrong. And by the time they get to be adults, most kids have lost that capacity. They have become frightened of being wrong...".

4. Analysis of the successful teacher and opportunities for the application of AI elements in the educational pedagogy. If the traditional education is based on the idea that in class the teacher speaks, and the students listen, in the modern reality the teacher should be able to listen as well. What's more – he has to do what is necessary to make his students feel engaged and start talking, which, for logical reasons, can not happen if he takes the floor all the time.

We often talk about the classroom of the future. For the general public, this is presumably a huge, spacious, solar-powered room that comes in with smart cards or iris identification. It has ultramodern lighting, filled with futuristic technologies, 3D reality and holographic wall maps that can be flexibly transformed into multimedia screens and, like the most advanced IMAX cinemas, immerse us in a variety of educational scenarios. This is quite likely to happen, but the true classroom of the future will be, above all, a virtual one. Cloud technologies now allow the collection and deployment of all the necessary educational information somewhere in the cloud so that it is permanently available and instantly accessible as long as the student has a suitable terminal device and a reliable online connection to take advantage of it. If we add stereo headsets and 3D glasses for virtual reality, this room can safely "follow" us everywhere, and thus the technological development will not prevent our prerecorded lectures from running in asymmetric mode, while in case we need to have live sessions with the teacher or our colleagues, this can easily be

accomplished with the available communication tools and dozens of friendly teamwork environments. The actual learning of the material should be gradual, with a consistent and purposeful engagement of the students with the problem because *the actual work in the process of learning is not done by the teacher but by the student's brain* – the good educator only needs to find the necessary levers to engage the mind of the learner, and he will do the rest on his own.

According to the majority of the modern educational experts, education must be more oriented towards the "things of life", and more and more information should reach the students without ideological, religious, nationalistic and other influences. If students are taught not just to follow pre-made templates but have the opportunity to "reach" the truth through experimentation and personal engagement, their development will be much more fulfilled with creativity and enthusiasm, and their empathy with the process will allow them to preserve and promote a lasting interest in the respective subject, which may even predifine their future career. Apparently, the technology, and artificial intelligence in particular, could play a significant role, as they could give students the tools they need to make such analyzes and the confidence to take the challenge.

In recent years, AI has been increasingly considered as a universal cure for everything concerning the penetration of humanity into the so-called "knowledge economy" – from the development of autonomous transport systems to new discoveries in nanoscience and biotechnology, the control of the climate change or the realization of the concept of "smart cities". Education, as one of the driving forces in the knowledge economy, can not stay away from this process. Of course, at the present stage of development of technology, we are not talking about replacing teachers with computers or robots, but artificial intelligence can be a valuable tool to illustrate the rationality of the learning process, a powerful tool for analysis and a catalyst for developing critical thinking among pupils from an early age regardless of the subject studied. Taking advantage of the computing power of the machines, we can compare different designs, ornaments, colors and shades, sounds and harmonies in seconds, to find the degree of similarity between different works of art, or even to discover cultural and historical ties between seemingly isolated cultures and events, embracing a rich variety of mathematical models that are not normally present in the traditional teacher's arsenal. However, artificial intelligence is not burdened like people with different emotional dogmas, self-assessments and personal feelings of "spirituality" and "holiness" of art, religion, or cultural identity. AI is often able to search for and find interconnections, which we normally would never thought existed, and the fact that self-learning computers

already successfully beat world champions of chess [15] or the Go game [3] is a clear indication that the rationality of the machine intelligence is now able, in a number of situations, to oppose to the best among people. And to beat them in a way that often seems unthinkable to us, but obviously works.

5. Human–AI interaction. With the development of the technology, it is becoming increasingly clear that in the quest for knowledge, the winning strategy is not to oppose to the machines but to try to understand what the positives are from using their capabilities to shape our own living philosophy by taking the best of the two worlds – the one of the computers and that of people. In purely scientific analysis, which should be based primarily on facts, people tend to miss details that may turn out to be significant at a later stage. We tend to subconsciously ignore facts that contradict to the theory and in the pursuit of inner harmony, we used to perceive many things for granted, while at the same time they are not undeniable. For example, for thousands of years, people thought that, in order to fly, a body must be lighter than the air (the dirigibles, that precede modern aviation, practically follow this concept), while at the same time birds are flying before their eyes, which obviously do not fit into the theory. An artificial intelligence would not face any problem to detect the contradiction instantly, but the prejudices and mental constraints that people put on themselves are among the main reasons why the discoveries literally bump into us and remain unnoticed. For example, the popular illusion (Fig. 4) of Johann Carl Friedrich Zölner [16], in which the parallel lines do not look such as they are crossed with small parallel lines at different angles, is a typical example of self-deception as a result of something that we take for granted, while the AI would simply calculate it without getting involved into assumptions.

Fig. 4. Zöllner illusion

Building of what we now call critical thinking, with the help of tools and models typical for AI, among contemporary school and university students is a key issue for the future of modern science. That is presumably because overcoming the status quo generates the progress, and the need for fresh "breakthrough" ideas is becoming increasingly critical in the ever-complicating social and economic interactions that determine the world agenda.

One of the upcoming trends of the new millennium is the job automation. According to the researcher Laura Tyson, "Advances in artificial intelligence and robotics are powering a new wave of automation, with machines matching or outperforming humans in a fast-growing range of tasks..." [14]. Apparently the acquisition of certain knowledge proves to be decisive for the personal competitiveness and in a knowledge-based economy, the more educated individuals are likely to succeed. Examples of this can be seen in statistics, for example, the level of people's education is a key factor in self-assessment of long-term labor market constraints due to disability [4], which means that even people with a certain degree of disability, but with higher education levels feel more competitive. What can we then say about a self-taught computer that can boot into its memory unlimited number of programs and perform them without interruption in 24/7 mode 365 days a year? Soon it would be obvious to everyone that in order to prosper, we must necessarily break the stereotype and open our minds to the new educational challenges because only they can guarantee our personal competitiveness in the long run. We do not have to fight robots or supercomputers, we just need to learn to co-operate with them. Obviously, people can not compute or work with large datasets faster than machines, but they can still take better decisions in a variety of situations as long as they can find the proper balance of confidence in technology and their own rational perception. Yes, people often make mistakes or take irrational, stupid and even tragic decisions when they do not have time or are pressed by the circumstances, but if we find a way to remove the limitations and one can fully use the capacity of the artificial intelligence in every moment, it is quite likely that the results would be very different.

According to many futurists, people can no longer rely on the purely evolutionary development opportunities in order to integrate adequately into the increasingly dynamic reality, which requires new senses or means for environmental interaction and an increasingly serious development of the so-called human-machine interface. Even if we ignore the achievements of the military industry and the concept of ultra-light exoskeletons, breathable fabrics, and self-regenerating alloys, the introduction of artificial bones, synthetic blood, built-in and self-adjusting lenses, or even brain implants are just a matter of

time and money. With the mass introduction of such technologies, they will logically become cheaper, and probably by the middle of the century modern people will enjoy swinging limbs, rejuvenation of tissues or even the ability to bring their minds into a new organism or even into a machine. Perceiving such "heresy" is not always easy for man's traditional perceptions of the world, and direct interference with his "divine" nature will be the subject of an increasingly common debate in the society, which should be initiated by the education. The AI can be perceived as a threat only by the people who are not ready to embrace it and merge with it in the future. Even nowadays we face dozens of situations where artificial intelligence systems already take critical decisions for us (such as an airplane autopilots, robots performing medical surgery, etc.), but we just need to gradually overcome our fears and prejudices, and that's where the good teacher could help us, including the sphere of social sciences, culture and art. "In this digital era, teachers' role has shifted from mere preacher to the manager of students social and emotions behaviours; mentor for their learning and overall development as a balanced citizen..." [1].

6. The modern education – a balance of technology, methodology and commitment. The technological devices are not, by themselves, a panacea for education [10] – the involvement of ICT in no way completes the modern education, and being too concentrated just on the technology can even lead to a blockage of the educational process (for example, the school says – we have no money for technology, so we will not train in a modern way and think innovative). In fact, it is just as silly as to declare that the Sun should not rise because we do not see it from our window. Obviously, technologies become cheaper over time, and ways to get them into the classroom are growing with unprecedented speed, so the lack of basic technical capabilities (such as the availability of an internet connection) could no longer be an excuse for anyone. Different governments or political regimes could always try to limit the use of ICT because they can reveal inconvenient truths, but this is a battle that has been lost long ago, so by the middle of the century we could confirm with reasonable assurance that there will be no man on the planet lacking technology access and it will depend entirely on him how he will be able to benefit from it.

With the advantage of 21st-century technology, the opportunities for personalized education are growing dramatically. The availability of intelligent training systems that could in just a couple of minutes take into account the personality, determine the language level or the sphere of interest and abilities of a student and generate flexible individualized curricula is far from fiction and

will soon become a routine. The role of the teacher, though key, will no longer concentrate on the daily, broadcast type of lectures, typical of the past (a recorded video would cover this and many modern educational institutions already record their lectures as a regular practice), but to the ability to provoke students and to participate in debates that reveal in depth the true beauty and challenge of the particular subject.

The educational transformation is not a hardware, but a software problem, and the basic idea is to learn to think in a new way, without necessarily denying everything that existed vefore. The artificial intelligence is not meant to replace the natural one, it only has to support it, and for many people the difference is not obvious and this should be carefully communicated with children at a very early age, before it becomes too late. It is not necessary for this symbiosis to happen in an antagonistic way. In fact, the artificial intelligence in most cases can imperceptibly adapt to the human needs without creating any moral or social problems. Indeed, even the inconspicuous approach is preferable "to capture the true intention of any given person, the smart methodology should investigate them in a noninvasive way." [13].

7. Conclusions. From the beginning of the century, education is at an important crossroad. On one hand, mankind's information capabilities have grown substantially over the last 2–3 decades, while education systems around the world have somehow "slept over" this dynamics and now need to catch up. The presence of competitive education is key not only for the development of individuals, but also for the survival of mankind and its integration into what we now call "knowledge economy". So to say "the emergence of the knowledge economy poses a new challenge for education" [5]. To meet this escalating dynamic, man faces serious challenges and without a revolutionary change in the way we train and educate, we will quickly be off the board [11].

The use of AI tools and systems to support and improve the learning process is an essential element of educational transformation as the information avalanche has long made the traditional educational practices inadequate to the needs of modern society. The inclusion of critical thinking elements in the classroom and the rational perception of AI's intervention in learning make possible the "peaceful" cohabitation of man and computer and the future development of mankind in a modern, dynamic and user-friendly oriented world. The essence of the future symbiosis of man and machine is the understanding that by acquiring the positives of artificial intelligence, man does not betray his identity but simply acquires new qualities and capabilities, so his emotional empathy in the process is quite important.

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