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Social Science Dimension of Engineering Curriculum Innovation

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Abstract

The paper deals with the humanization of technical education and other related updates of the engineering disciplines' curriculum based on interdisciplinary cooperation. The synergy of social sciences and engineering disciplines enables a complex view of the interaction of man, society and technology. Firstly, it accentuates the perspective of the human factor in situations where technical solutions fail. Secondly, it reflects psychosocial needs, and lastly, it predicts the potential individual and social impacts of innovation at the philosophical, psychological, sociological and political level. The paper is focused on the analysis of institutional and content possibilities as well as on the limits of cooperation of technical and social sciences in the development of the engineering disciplines' curriculum. The methodology of the paper is based on a monographic study of the intended innovation of the curriculum of the engineering courses at VŠB-TU Ostrava as well as on the document analysis and data analysis.

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Humanization
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Algorithms
Artificial intelligence
Dataism

1 Introduction

Interdisciplinary cooperation has been an attribute of relevant scientific research for many years. However, the initial euphoria of scientific discoveries and innovations is rarely affected by concerns about the unintended consequences of their practical application.

The obstacles to be considered include the limitation of the application field by legislative standards or the economic aspects of the transposition of the new technology from laboratory conditions into production practice. The secret prerequisite for the introduction of technological innovations is their undeniable benefit to individuals, social groups or society as a whole. Possible negative consequences remain below the threshold of recognition if they are not in direct conflict with binding standards and if they can be offset by positive impacts in the relevant area. However, the more rapid the technological development and the greater the social role of new technologies, the more carefully the impact of new technologies on the life of an individual and the functioning of society should be considered.

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The aim of technical education should be, among other things, to make students aware of the interconnection of their professional knowledge and professional skills with the existence and functioning of social structures, the social policy system and its legal framework and last but not least with the psychological aspects of scientific innovation. The acquired competence should be the ability to identify and interpret the psychosocial context of the development and implementation of technological innovations, the positive and negative impacts, opportunities and risks for the daily life of the individual and the stability of society.

2 Dialectic between the technical and the humanistic

The relationship between man and technology has become so natural that we can say without exaggeration that we find ourselves at a point where our self-understanding and understanding of the world are completely defined by new technologies: algorithms tell more about us than we are able to find out about ourselves. (Floridi 2019)

The position between these technologies brings a certain need for orientation, a cognitive mapping (Jameson 2016), which needs to be supported by scientific methods and specific education. Indeed, the importance of technology is expected to continue to rise. (National Artificial Intelligence Strategy of the Czech Republic, 2019)

The implementation of new technologies, however, faces a major problem, caused by Moore's law: every 18 months the performance of computing circuits doubles, implying that technologies are developing at enormous speeds (exponentially). (Keen 2019)

If we look at this problem holistically, it means that technologies evolve faster than we are able to reflect on the level of the relationship between society and technology. If at all we were able to do a wider reflection, we would not be able to implement this technology anyway. We cannot fully exploit the potential of algorithms and artificial intelligence because we do not have sufficient legal framework for them. As new technologies evolve, new situations arise that have not yet been evaluated from a legal and societal perspective. Thus, logically, the development of normative frameworks in the form of specific laws is slower than the development of technology itself. (Analysis of legal-ethical aspects of artificial intelligence development 2018)
Consider an example of an artificial autonomous agent. If the selected technology is autonomous, it will be able to make decisions in selected situations (eg autonomous vehicle). Here the problem arises because we have to ensure beforehand what ethical concept this decision will follow; it cannot be completely arbitrary. However, artificial intelligence or algorithms are governed by formal rules, there is no room for randomness (as is the case with human impulsive decision-making), which poses a difficult task of choosing which ethics to put into the algorithm. How should an autonomous vehicle decide during a crisis? Weak artificial intelligence is based on the rules of formal language, which means that decision-making does not involve chance or vagueness, but logic, mathematical models, statistics, or game theory outcomes. (Barták 2017)

This means that if the system faces a dilemma, we must offer it a specific solution to this dilemma (eg an accident of an autonomous vehicle at a crossroads), ie we have to put some decision into the algorithm beforehand (these problems are being explored by eg the Karel Čapek Centre in the Czech Republic). Here we cannot do without philosophy and ethics, which has been involved in decision-making for over 2,500 years.

2.1 Social, legal and ethical aspects of artificial intelligence

A technically focused scientist or expert cannot answer the question above. He/she is able to design an autonomous system but is not able to insert a selected ethical concept into it. It is therefore necessary to link technological knowledge with the knowledge of humanities. Only by linking the descriptive and the normative will we be able to truly use the potential of new technologies. There is therefore a demand for a specialist who will know both technical and social sciences. Therefore, new disciplines – such as the ethics of artificial intelligence – need to be considered, which would be capable of producing such professionals and thus satisfying the emerging market demand. However, the need for these professionals is not only for the sake of knowledge of ethics, but also to maintain a cultivated development of technology and innovation. Data will be the main commodity and it will be up to us how we approach this challenge. (Ross 2019)

The use of ethical principles in the research and development of artificial intelligence also raises the question of social control of science and technology in terms of analyzing opportunities and risks that the technological advancement can create for security, democracy, environmental sustainability, social ties and community life, value systems etc. There is a presumption of the positive social potential of artificial intelligence in terms of supporting and securing the functioning of key subsystems of society without unspoken stereotypes, prejudices and hidden discriminatory actions. Also the presumption of the possibilities to change the structure of work and non-work time as a result of the reduction of activities performed by people and thus the expansion of opportunities for social activities (development of social relations, community life, volunteering, etc.). The negative impacts of the development and implementation (or expansion) of artificial intelligence may be reflected in economic, political and social terms (insufficient socio-political reflection of changes in the structure of the labour market, abuse of AI by undemocratic regimes, limited possibilities of controlling AI, etc.). There are still unanswered questions, such as who and how should be involved in the decision-making in the development and implementation of innovations, what criteria should be used to set priorities for R&D funding, how society should measure risks and formulate safety standards, whether and how experts are obliged to communicate their decisions and their reasoning to the public, etc.

2.2 Technological limits

The aforementioned Moore's law is not the only cause of uncontrollable progress. Today's technologies can be sophisticatedly linked, allowing us to take existing technologies and services in a new direction. (Brynjolfsson 2015)

A representative example is the Waze transport application, which could only be developed on the platform of online maps, cloud computing and the development of smartphones that feed the application with data. This is the way new start-ups are heading, trying to come up with innovations by interconnecting current technologies. However, there is a need to know the current societal needs and problems to which these technologies could respond and be useful. This knowledge does not come without the social science paradigm. Start-ups are now dominated by good ideas, rather than knowledge of technologies themselves. For example, they could respond to current environmental crises and come up with relevant solutions.

However, we should not forget the negative side of current technologies. An example of this is Lucian Floridi's book, which focuses on the so-called expansion of the infosphere at the expense of the biosphere. Floridi warns that the introduction and spreading of technology is at the expense of nature and that the infosphere is growing faster than its political reflection and the creation of measures to keep it in check. Although in political societies the risk of using technology is regulated (standards, protocols, licenses, terms of use, etc.), the so-called meta-technologies must be constantly established (Floridi 2019).

We may believe that information and communication technologies can help us, for example, tackle environmental issues, but the risks that this entails if we use the technologies incorrectly should be taken into account. This is a problem of energy consumption of these systems (Internet of Things, clouds and big data). Contemporary dataism cannot do without big data storage and high computing power (Harari 2017). We rely on the thought that we have invented potential tools to save the environment (AI and algorithms, automation, centralization of production – easing logistics of goods or additive manufacturing), but these will only have a positive impact if they are used rationally, at specific sub-points; their blanket use is detrimental. If we do not regulate these systems, they will produce more carbon footprint in 2020 than the aviation industry (ibid. 2019).

3 Psychological aspects of artificial intelligence

The aim of technical education in general is to achieve and develop an individual's technical literacy. Technical literacy means the ability of a human being to understand and use technical processes, to assess and identify the right technologies and approaches. It is a knowledge and understanding of basic technical relations. One of the fields, which is currently gaining great interest mainly due to application needs, is informatics, the teaching of which at VŠB – Technical University of Ostrava is provided by the Faculty of Electrical Engineering and Computer Science. Informatics would seem to be a purely technical science, but to understand many contexts, especially in the field of artificial intelligence, it is necessary to connect it with the humanities and use the knowledge collected therein.

Although many people may regard psychology as a purely human science and informatics as a purely technical science, these two disciplines have more in common than the general public might see at first sight. The chapter of scientific psychology began in 1879 in the laboratory of Wilhelm Wundt in Leipzig (Plháková 2006). However, psychology as such has been developing since antiquity. The development of computer technology came much later, dating back to the Second World War, which has brought tremendous technical progress through the advent of technology from the military to the civilian sphere. In fifty years, computer technology has made an incredible leap forward. For example, as early as 1997, an IBM computer managed to defeat the world chess champion Garri Kasparov.

In 1950, Alan Turing began to question whether machines could think, whether a computer could deceive a person and persuade them that it was also a human (Sternberg 2009). In 1950, Turing published an article in the Mind scientific journal titled Computing Machinery and Intelligence, in which he presented his now well-known idea of an imitation game.

Many objections have been raised against this type of test. One of them comes from John Searl in 1980. Searl states that the ability of a computer to respond is not enough proof of understanding, which is what we expect from strong artificial intelligence. According to Searl, the computer can only mechanically imitate its thinking, the machine will never understand the meaning of symbols, which Turing has neglected.

Many scientists are trying to create a supercomputer that could at least in part work like a human brain. Computers and robots are not yet capable of incorporating human-like thinking and self-awareness. However, there are many similarities in the functioning of the computer and the brain. Neural networks are one of the main areas of study in artificial intelligence. Many experts focus on self-awareness. Some of them claim, based on tests, that the robot is capable of self-awareness by being able to correct itself when making a mistake. Expert critics argue that programming a robot to correct itself does not testify to its self-awareness. Some even argue that people will never be able to create a robot that accepts emotions as its own. Artificial algorithms alone cannot encompass as complex processes as our organism (Anathaswamy 2014). Hormones, chemical and biological processes play a major role in human behaviour. According to James-Lange theory, many emotions arise based on psychosomatic manifestations, not vice versa (Dalgleish 2004). According to this theory then, an artificial intelligence robot should be able to evoke emotions based on events inside itself, not just in response to external stimuli. Robots will surely be able to imitate human nonverbal communication, our facial expressions and gestures within a few years. However, this artificial expression of emotions does not equal real emotions.

Another link between the functioning of human thinking and computer function are computer languages, which are tasked to translate the user's intention (human requirements) into a "language" that a computer would understand. Among other things, programmes use variables, which we usually have to define in advance. If I define the variable a, we can create an imaginary parallel with a concept from the human world. For example, the concept of flower includes many properties (colour, size, our relationship to it, etc.), but a human has it stored in their memory as a flower. Similarly to a programme, we store the variable a with certain properties in our memory, but to simplify further work we can only reference the variable; there is no need to re-enter its properties. This concept is very simplified, yet it serves to give a simple picture of the similarity between human thought and computer.

3.1 Intelligence and Artificial Intelligence

The effort of current researches is to create a programme, which would demonstrate a certain intelligence. Intelligence in this sense may be understood as the ability to adapt to the environment or the ability to independently solve complex problems which has never been solved previously by the programme and to make decisions spontaneously.

Artificial intelligence can be described as a property of artificially created systems that exhibits features similar to human intelligence. Searle is the author of the well-known distinction between weak and strong artificial intelligence. If the machines (or programmes) act outwardly as intelligent, it is weak AI. To speak of strong AI, not only the external form and results of the thinking processes but also the internal mechanism must match that of a human. The computer should imitate as closely as possible all aspects of the human brain activity. The implementation of strong artificial intelligence in principle leads to the design of a new artificial man. On the contrary, weak artificial intelligence helps formalize certain specific areas of human reasoning and behaviour. It suggests algorithms that often solve these areas better than humans. Examples include various games, machine control, optimization tasks, modelling, etc.

The term artificial intelligence also signifies interdisciplinary science discipline on the intersection of cognitive sciences, cybernetics and computer science. This discipline researches and models intelligence in order to develop software and hardware that will use procedures considered as manifestations of human intelligence to solve tasks. The basic areas of research in artificial intelligence include general problem solving, planning, recognition, knowledge representation, adaptation and machine learning. Expert systems, natural language processing, computer vision, robotics and neural networks are currently being developed as application areas in the field of artificial intelligence.

One of the most striking trends in contemporary psychology is cognitive psychology. It emphasizes the importance of cognitive processes in human psyche and behaviour and focuses on studying them. It does not study mental states, but the processes by which one gets to know oneself and the world around them.

Cognitive psychology has taken over from computer science the concept of a human as a system capable of handling symbols. This fact has given rise to the computer theory of perception, modelling of imagination, as well as problem-solving programmes. Most research, however, does not confirm a qualitative analogy between the processing of information by man and computer. Some works emphasize more the subjective factors that affect information processing (Eysenck, Keane 2008).

In a broader sense, this science focuses not only on humans or the purely cognitive and rational component of their mind but also seeks to compare and generalize human as well as artificial (computer) thinking. This discipline is not limited to cognitive processes in the strict sense (eg perception, learning), but is interested in the abilities of the mind in the broadest sense (rational and irrational behaviour, memory, communication, creative activity, intentionality, consciousness). The starting and finishing point of cognitive science is the interaction and cooperation of various scientific disciplines that are otherwise quite remote: psychology, neuroscience, cybernetics, artificial intelligence, linguistics, philosophy of the mind. There are three general approaches to the exploration of the natural mind, which are methodologically different and that is why they can be inspiring for cognitive science. The first approach is the path of inner experience, introspection and phenomenology (represented in part by psychology and part by philosophy), the second is the path of objective natural sciences based on observation, measurement and laboratory experiments (biology, neurosciences, part of psychology), the third path is constructive – it creates artificial mathematical, computer, physical or physics models (cybernetics, artificial intelligence).

4 Engineering fields curriculum innovation

The aforementioned thematic areas are the focus of the intended innovation of the curriculum of engineering fields prepared by the Department of Social Sciences of the Technical University of Ostrava. The aim of this innovation is the introduction of courses and, prospectively, a field of study that will focus on the social, psychological, legal and ethical aspects of technological innovations, particularly in relation to the development of industry 4.0 (and 5.0 further on) and on utilizing the potential of artificial intelligence.

The curriculum innovation reflects current societal changes in the area of market demand while respecting the demand for interdisciplinary cooperation. It focuses on the development of students' specific competences that combine technical knowledge and skills with the knowledge of the current social context, and also aims to support and develop the ability of critical analysis. The theoretical and methodological groundwork of the presented innovation is provided by the outcomes of the project of the Technology Agency of the Czech Republic named Development of the theoretical-application frameworks for a social change in the reality of the transformation of industry (TL01000299); the project owners are members of the Department of Social Sciences of VŠB-TUO.

The project focuses on the current rapid development of industry and technologies, where the relationship between artificial intelligence and social morality requires a paradigm shift in the areas of work, responsibility, education, productivity, etc. The aim is an interdisciplinary analysis of current risks and their tendencies in the field of the human-machine relationship and consequently the creation of practical application frameworks for creative implementers of educational, social and employment procedures. The interconnection of the project outputs and the starting points for updating the curriculum of engineering courses ensures a content up-to-dateness and relevance of the prepared courses. At the same time, it enables responding to identified specific knowledge and skills demanded by the labour market through the teaching of desirable competencies (the TACR project is also based on the cooperation of VŠB-TUO with the Confederation of Industry of the Czech Republic).

The technological development in the context of the ongoing industrial and/or digital revolution brings with it the transformation of a lifestyle, cultural patterns, cognitive and interpretation schemes. Reflecting new social patterns and standards, the needs of individuals and social groups regarding their quality of life is a prerequisite for sustainable research, development and innovation. The synergy of social sciences with engineering disciplines enables a comprehensive understanding of human/society interaction with technology. Interdisciplinary and academic/corporate interactions guarantee desirable results in education, science and research and industrial development alike.

5 Conclusion

The current rapid technological development requires a reflection on the social, economic, political and legal context and its conscious preparation for the upcoming innovations that affect all areas of society. It is desirable that field specialists, engineers, scientists and researchers realize that the current transformation of industry and technological change inherently have social consequences. Therefore, courses, classes and study programmes aimed at identifying and interpreting the social, psychological, legal and ethical dimensions of research and development are a necessary part of the curriculum of engineering disciplines. The course and the upcoming study programme of the Department of Social Sciences of VŠB-TUO, which is methodologically based on the outputs of the project of the Technology Agency of the Czech Republic, reflect current labour market requirements for specific competences on one hand and for critical thinking and the ability to solve unexpected, unstructured problems on the level of multidisciplinary analysis on the other hand. The precondition for forming a competitive graduate is interdisciplinary cooperation in teaching and research, and cooperation between academia and industry practice.

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