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Significance of CAx Technologies in Industry 4.0: The Path from Education 4.0 to Industry 4.0 Through Lifelong Learning in Metal Processing Industry

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Abstract – The implementation of CAx in Industry 4.0 (I4.0) enhances product development, manufacturing processes, and maintenance activities by leveraging digital technologies, connectivity, and data analytics. These implementations enable increased automation, improved productivity, better decision-making, and enhanced product quality in the context of Industry 4.0. One of the goals of the Education 4.0 is to define plans and programs for retraining, continuous learning and training of students, engineers, etc., that is, the development of higher technical education during the implementation of CAx technologies in accordance with the requirements of I4.0. This will lead to improve the level of competence and skills of teachers, engineers and students, related to CAx technologies. The education 4.0 is significant from the point of view of connecting the University and the enterprises through the development of lifelong education in the the enterprises, as well as from the aspects of the application of smart technology in I4.0

Keywords: CAx, Lifelong Learning, Industry 4.0, Education 4.0

I. INTRODUCTION

The metal processing industry (MPI) is the starting point of all production activities and is currently undergoing rapid and continuous changes, because of the Fourth industrial revolution Industry 4.0 (I4.0). Metal processing industry (especial automotive and machine tools manufacturing) is a major driver of Industry 4.0 (I4.0) technologies and of economic wealth in industrialized countries. Although the main sources of professionals for this industry are still universities and research institutes, teaching and training have not kept pace with the advances in technology [1]. Although Industry 4.0 aspects have been deployed within the automotive industry, educational institutions are striving hard to adapt to this latest industry trend [2]. I4.0 is primarily associated with digitization, robotization, the Internet of Things, etc., basically with smart technologies. But the basis of I4.0, which derives from its very name, is production systems, and in them the systems and methods of CAx technologies. Most of the smart technologies used by I4.0 in the metalworking industry are based on digital CAx models. The integration of CAx technologies from the aspect of I4.0 requires the development of new technological and transversal skills among the workforce, especially engineers, as carriers of the economic development of a country. The main requirement for the creation of this highly qualified workforce is the retraining and training of the existing and new workforce to easily adapt to the introduction and use of smart technologies. Significant support can be provided to the metal processing industry, especially to micro, small and medium enterprises (MSMEs) through training and professional development in schools, universities, and other higher education institutions. MSMEs face significantly more challenges in the digital transformation process than large corporations. They may struggle to keep up with digitalization, especially in terms of implementing new technologies and training the workforce. In the last few years, many authors have been dealing with Education 4.0 and its implementation in Industry 4.0. Akyazi et al. [3] presented the current and foreseen skills requirements demanded by the machine tool industry workforce. To this end, they generated an integrated database for the sector with the present and prospective skills needs of the metal processing sector professionals. Transformations based on the definition of three pillars (didactic, integrative and engineering) for the development of a learning factories were

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proposed in [4]. Other hand, the current technological transformation, and the main developments funded by European Research Programs was analyzed in [5]. Chen et al. [6] proposed hierarchical architecture of the smart factory, and then the key technologies were analyzed from the aspects of the physical resource layer, the network layer, and the data application layer. Within the context of modern manufacturing techniques in the Industry 4.0 era and advanced tools for analysis and mechanical design, in [7] is describes the development of a virtual/augmented reality.

(VR/AR) laboratory to support learning, training, and collaborative ventures related to additive manufacturing for the automotive industry. Computer supported technology (CAx) is used today in all phases of development and production cycle of a product, from development of a concept products, through designing, prototyping and testing, to preparation of processing programs on CNC machines. Fernandes et al. [8], presented a teaching methodology based on a Problem-based learning (PBL) approach as a learning tool for integration of CAx in mechanical engineering curricula. Teaching CAx tools with project-based learning in virtual distance education was shown in [9]. Markovic et al. [10] presented the relevance of the traditional education system, which is still dominant in Bosnia and Herzegovina, and the need for faster changes in teaching programs and plans, with an emphasis on the high school level of education, as a preparation for higher education.

II. EDUCATION 4.0: SIGNIFICANCE AND MOTIVATION

Education 4.0 aims to prepare students for the challenges and opportunities presented by emerging technologies, automation, and digitalization. The main objectives of Education 4.0 include:

- *Developing Future-Ready Skills*: Education 4.0 focuses on equipping students with the skills necessary for the digital age. These skills include critical thinking, problem-solving, creativity, collaboration, digital literacy, and adaptability. The goal is to prepare students for the changing job market and enable them to succeed in a technology-driven society.
- *Integrating Technology*: Education 4.0 emphasizes the integration of technology in the teaching and learning process. This includes leveraging tools such as computers, tablets, interactive whiteboards, educational software, and online platforms. Technology is used to enhance the learning experience, provide personalized learning opportunities, and enable access to a wealth of educational resources.
- *Promoting Active and Experiential Learning*: Education 4.0 encourages active and experiential learning approaches. Students are actively engaged in the learning process through hands-on activities, project-based learning, simulations, virtual reality, and augmented reality. These methods promote student-centered learning, encourage critical thinking, and foster creativity.
- *Emphasizing Lifelong Learning*: Education 4.0 recognizes the importance of lifelong learning in a rapidly changing world. It aims to develop a culture of continuous learning, where individuals have the motivation and skills to update their knowledge and adapt to new technologies throughout their lives. Education 4.0 promotes self-directed learning, online courses, and other flexible learning options to support lifelong learning.
- *Fostering Global Citizenship*: Education 4.0 emphasizes the development of global citizenship skills. It promotes cultural understanding, empathy, and collaboration across borders. Students are encouraged to think globally, appreciate diversity, and address global challenges such as sustainability, climate change, and social justice.
- *Enhancing Personalized Learning*: Education 4.0 recognizes that every student has unique strengths, weaknesses, and learning styles. It promotes personalized learning approaches that cater to individual student needs and preferences. Adaptive learning platforms, data analytics, and artificial intelligence are used to tailor educational experiences and provide personalized feedback.
- *Encouraging Entrepreneurship and Innovation*: Education 4.0 aims to foster an entrepreneurial mindset and cultivate innovation among students. It encourages creativity, problem-solving, and risk-taking. Students are encouraged to develop an entrepreneurial mindset, think critically, and identify opportunities for innovation.

These objectives of Education 4.0 are aligned with the demands of the modern workforce and society, aiming to prepare students to thrive in a technology-driven, interconnected world.

Industry 4.0 refers to the integration of advanced technologies, such as artificial intelligence, automation, robotics, big data, and the Internet of Things, into various industries. In this context, the importance of Education 4.0 becomes crucial. Main reasons why Education 4.0 is essential in Industry 4.0:

Preparing a future-ready workforce: Industry 4.0 is characterized by rapid technological advancements that reshape job requirements. Education 4.0 equips students with the skills, knowledge, and competencies needed to thrive in the digital era. It focuses on critical thinking, problem-solving, creativity, digital literacy, and adaptability, enabling individuals to adapt to new technologies and job roles effectively.

Bridging the skills gap: Industry 4.0 demands a highly skilled workforce, but there is often a gap between the skills required by the industry and those possessed by the workforce. Education 4.0 aims to bridge this gap by aligning educational curricula with the evolving needs of the job market. It incorporates

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emerging technologies into educational programs, providing students with hands-on experiences and practical skills relevant to the digital age.

Fostering innovation and entrepreneurship: Industry 4.0 thrives on innovation and entrepreneurship. Education 4.0 encourages a mindset of innovation, creativity, and risk-taking. It emphasizes problem-solving, design thinking, and collaboration, empowering students to develop innovative solutions to real-world challenges. By nurturing an entrepreneurial spirit, Education 4.0 prepares individuals to drive innovation and contribute to economic growth.

Lifelong learning and adaptability: In the fast-paced and ever-changing landscape of Industry 4.0, continuous learning and adaptability are crucial. Education 4.0 emphasizes lifelong learning by promoting a culture of curiosity, self-directed learning, and continuous skill development. It equips individuals with the ability to learn and adapt to new technologies, ensuring their employability and relevance in the evolving job market.

Ethical and responsible use of technology: Industry 4.0 brings ethical challenges and considerations related to data privacy, cyber security, AI ethics, and automation's impact on jobs. Education 4.0 addresses these concerns by incorporating ethical frameworks and fostering responsible digital citizenship. It promotes ethical decision-making, critical evaluation of technology's impact, and the development of responsible practices in utilizing advanced technologies.

Collaboration and global connectivity: Industry 4.0 emphasizes global connectivity and collaboration. Education 4.0 utilizes digital tools and platforms to facilitate global collaboration among students, educators, and experts. It encourages cross-cultural understanding, teamwork, and the exchange of ideas and knowledge across borders, preparing individuals for globalized workplaces and enhancing innovation through diverse perspectives.

In summary, Education 4.0 plays a vital role in Industry 4.0 by preparing individuals with the necessary skills, knowledge, and mindset to navigate the digital era successfully. It bridges the skills gap, fosters innovation, promotes lifelong learning, addresses ethical considerations, and enhances collaboration and global connectivity. By embracing Education 4.0, societies can leverage the opportunities of Industry 4.0 and empower individuals to thrive in the digital age.

III. THE NEED FOR CAx TECHNOLOGIES IN INDUSTRY 4.0

A. *CAx technologies in metal processing industry*

The metal processing industry (MPI) is the starting point of all production activities and is currently undergoing rapid and continuous changes, because of the Fourth industrial revolution Industry 4.0 (I4.0). The MPI is under increasing pressure due to competition, the need for lower prices and shorter production time and the decline in the skill level of employees in the industry. This industry enables the production of both machine tools and components for key industries such as automotive, aviation, medical and many others. Due to the high degree of customization and variety in terms of size and material being processed, degree of automation, regime processing, MPI is currently undergoing rapid and continuous changes, because of the fourth industrial revolution Industry 4.0. Key the principle of Industry 4.0 is to increase knowledge of the process through data collection and monitoring. One of the primary technologies in the Industry 4.0 concept refers to Smart maintenance or predictive maintenance that includes continuous or periodic sensor monitoring of physical changes in the condition of manufacturing resources [11]. The production processes are deeply transforming with the development of digitalization. Fourth industrial revolution is usually identified with broadly understood digitization. Digital transformation is a dominant factor of the ongoing industrial revolution leading to revolution of traditional industries through intelligent (smart) production. As a result, the development of digitization has changed the progress in the most industries, in addition to the metalworking industry. Models' production continues to develop with ongoing progress in smart technologies such as the new generation of sensors, advanced robotics, artificial intelligence (AI), virtual reality (VR), augmented virtual reality (AVR) Internet of Things (IoT), machine learning, Internet of Service (IoS), digital twins, cyber-physical systems (CPS), cloud computing, machine-to-machine (M2M) communication, etc. These technologies can equally apply to new production facilities or to existing production facilities, which leads to transformation of traditional manufacturing companies into intelligent manufacturing systems called "smart factories".

Since the MPI, responsible for providing a wide range of customer services, including maintenance, collection and analysis of data in real time through internet, sensors, machine learning, etc., smart technologies have a significant advantage for them. Industry 4.0 represents an invaluable opportunity for the MPI because it reshapes and improves not only all production processes and business models but also the quality of their services. Therefore, Industry 4.0 could be seen as an invaluable opportunity for MPI, only if the industry has competent workforce capable of handling the implementation of new business models, technical and technological development. Generally, the integration of digital innovations requires the development of new technologies and transversal skills among the workforces. The main condition for creating this highly qualified workforce is retraining of the existing workforce and training of new ones to easily adapt to the introduction and use of smart technologies.

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The MPI urgently needs to build a competent, multi-skilled workforce that is capable to deal with technological development and implementation of new one's business models. Only engineers with upgraded skills, knowledge and credentials will have enough ability to quickly adapt to the digital transition and newly adopted work systems, so as to enable the industry to keep pace with digitization. Disruption of traditional industrial practices and processes is inevitable. The MPI is no exception. The development of smart technology opens new and extremely powerful possibilities for us that help us gain a much deeper understanding of the fundamental processes in this industry.

On the other hand, all phases are applied in the MPI product life cycle from development through design, analysis and optimization, to the development of prototypes, testing, production of technical documentation and at the end of production, etc. which are supported by CAx technologies. Development and introduction of smart technology allows companies to optimize these processes, increase efficiency and reduce scrap through the new phase of automation. Today's competitive market has created a very challenging environment for product development. Companies are under bigger pressure to maintain their competitive advantages by reducing the time and costs of product development with maintaining a high level of quality. Therefore, it is necessary to take all measures to enable a robust, error-free and economical production in the early design phase.

The new era of digitization opens a completely new environment with powerful new possibilities for achieving economic production and the required processing quality. Production remains a key activity for any nation. Production itself is facing rapid progress in production technologies, tools and techniques. Therefore, production is entering a new era, in which students, workers and engineers need new schemes of continuous learning to keep pace with this progress. Education in production and education for production is considered the main driver for creation of new generations of "knowledge workers" in production. However, teaching and training in and for production did not keep pace with the progress of production technology, nor with requirements of the labor market. Current practice has shortcomings in providing continuous, multidisciplinary education and training of employees in production. Therefore, there is a lack of guidelines for policy makers in the field of education, which enables that relevant subject curricula and programs of continuing education are compatible with needs of the industry. In fact, traditional methods of training and education show limited efficiency in the development of competences of employees and students for current and future production environment. Cutting processing as a dominant factor in the metal processing industry occupies an important place in industrial practice and university research. Today, cutting processing does not cover the narrow-specialized field of metal cutting, but as a part of production technologies stimulates development in a wide range of machine tool production, such as innovative products, machine tool performance, advanced materials, new ways organization of production, implementation of the CAx system in processing technologies, etc.

B. *CAx technologies in Education 4.0 and Industry 4.0*

It is striking that most of the research and studies dealing with industry 4.0, are focused mainly on IT aspects. Smaller attention is paid to the activities carried out in the areas of development, design, analysis and product control, preparation of production process or its execution, that is, areas of the product life cycle that takes place in a certain manufacturing company (from product design to its sales). It is in these activities that products acquire properties which their future customer and user expects. To properly use smart technologies (e.g. created model VR, AVR and digital twin, etc.), knowledge of CAD/CAE program systems is required. Also, to perform processing of the physical or digital model on CNC machines with tools (physical or virtual) and performe physical or digital model control some CAD/CAM/CMM software systems skills are required. Most of the smart technologies useful to Industry 4.0 in the metalworking industry is based on CAx models. As is known, Industry 4.0 is a collective term that stands for the integration of intelligent machines, systems and introduction of changes in production processes aimed at increasing production efficiency and implementing the possibility of flexible changes in product range. But the basis of Industry 4.0, which derives from its very name, are production systems, and within them the systems and methods of CAx technologies. These technologies are essential for achieving the goals of I4.0, which include increased automation, connectivity, data exchange, and intelligent decision-making.

Computer-Aided Design (CAD): CAD systems enable engineers and designers to create digital models of products or components. In I4.0, CAD systems facilitate the integration of digital models with other systems, such as simulation, virtual reality, and augmented reality. This integration allows for virtual product testing, rapid prototyping, and real-time collaboration between designers and other stakeholders.

Computer-Aided Engineering (CAE): CAE tools are used for simulating and analyzing product performance under various conditions. In I4.0, CAE systems leverage data from sensors, Internet of Things (IoT) devices, and digital twins to perform real-time simulations and predictive analysis. This helps in optimizing product designs, predicting maintenance requirements, and improving overall efficiency.

Computer-Aided Manufacturing (CAM): CAM systems generate instructions for manufacturing

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processes based on the digital models created in CAD. In I4.0, CAM systems are integrated with other manufacturing technologies such as robotics, additive manufacturing, and CNC machines. This integration enables the automation of production processes, adaptive manufacturing based on real-time data, and improved production flexibility.

Computer-Aided Inspection (CAI): CAI systems use various inspection techniques such as coordinate measuring machines (CMMs) and optical scanners to verify product quality and dimensions. In I4.0, CAI systems are integrated with other technologies like IoT, data analytics, and machine learning. This integration allows for real-time inspection data analysis, early detection of defects, and predictive maintenance of inspection equipment.

Computer-Aided Process Planning (CAPP): CAPP systems assist in creating optimized manufacturing process plans for producing a product. In Industry 4.0, CAPP systems integrate with other technologies such as digital twin simulations, IoT, and real-time data analytics. This integration enables dynamic process planning, adaptive manufacturing, and efficient utilization of resources based on real-time production data.

Computer-Aided Simulation (CAS): CAS tools enable the virtual simulation of manufacturing processes, assembly operations, and production lines. In E4.0 and I4.0, CAS systems leverage digital twins, IoT data, and machine learning algorithms to simulate and optimize complex manufacturing scenarios. This helps in reducing production lead time, identifying bottlenecks, and improving overall production efficiency.

Computer-Aided Robotics (CAR): CAR systems focus on the integration of robots and automation technologies in manufacturing processes. In I4.0 and E4.0, CAR systems leverage advanced robotics, collaborative robots (cobots), and artificial intelligence (AI) algorithms to enable flexible and intelligent automation. These systems enhance productivity, safety, and adaptability in manufacturing environments.

Computer-Aided Training (CAT): CAT systems provide virtual training and simulation environments for workers to learn and practice manufacturing processes and operations. In Education 4.0, CAT systems incorporate augmented reality (AR) and virtual reality (VR) technologies to create immersive training experiences. This helps in improving worker skills, reducing training time, and ensuring safety in complex manufacturing settings.

Computer-Aided Collaboration (CAC): CAC tools facilitate collaborative work and communication among different stakeholders involved in the product lifecycle, including designers, engineers, manufacturers, and suppliers. In Industry 4.0, CAC systems incorporate cloud-based platforms, digital workspaces, and real-time communication tools to enable seamless collaboration, version control, and knowledge sharing across geographically dispersed teams.

These CAx technologies play a key role in the transformation of traditional industries into digitalized and connected production environments that characterize Industry 4.0. They enable companies to achieve greater efficiency, quality and innovation, leading to a competitive advantage in the global market.

Integrated CAx systems are of great importance in implementation smart technologies, especially in cases where components of the same purpose can differ from one another due to variety of assemblies in which they are used. In such cases, engineers try to use CAx systems which, on the one hand, enable a flexible response to customer requests, and on the other hand, maximize the standardization of used technical solutions. CAx integration provides efficient data exchange between all parties involved in product development and product launch, as well as ease of editing and changes in the project. Thanks to the work into the cloud (Cloud Computing) access to all system resources (i data and executable applications) is possible from any device connected to the Internet, and designers have great flexibility in exchange of information. On the other hand, thanks to the numerical simulation (CAE technology, digital twin VR, AVR) each change to the product and/or process can be made quickly, easily and analyzed with relatively low costs.

Transition of labor force cannot be solved by conventional training in companies. Nor can this vital transition be fully handed over to manufacturers of CAx system programs; most of their training courses are focused on their latest software and therefore probably lacks the necessary depth and breadth especially in areas of process improvement. Therefore, constant improvement and the education of the workforce, students, etc., is based on CAx systems basis for their easy adaptation, use and introduction of smart technologies into the production environment.

Application of smart technologies in development pf new and improvement of existing production processes in regional companies and MSMPs will represent a key activator of productivity growth, and therefore, economic development and prosperity for the whole population of the Western Balkan region. MSMP, according to opinion of many experts, are the basis of the economies of developing countries. That specially applies to the economy of Central European countries, which previously had a non-market economy.

IV. CONCLUSION

Development of the mentioned industrial enterprises today depends on the appropriate level of knowledge and engineers who deal with design, production of mechanical engineering and production management. Significant support can be provided to

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the metal processing industry, especially to micro, small and medium enterprises (MSMPs) through well-targeted support measures at EU and national levels, as well as through European training and professional frameworks development in schools, universities, and other higher education institutions and companies. Given that about 98% of active companies engaged in metal processing in the Western region Balkans (Serbia, Montenegro, Bosnia and Herzegovina, Croatia) categorized as MSME, with needs and operational procedures completely different from those in large corporations, education should be focused on the development of global system support in continuous education, training and courses for engineers, students and teachers for those companies. The MPI is characterized by intensive use of computers, communication and information technology. Listed facts that are related to this issue suggest that the educational system should prepare plans and programs, for retraining, continuous learning and training of the workforce for future practice. This is the main task of the university, but it could be done only with close cooperation between the Industry and the University. As is known, each university (technical institution) has its strong point in research and education. Therefore, experts based in knowledge and skills must be well prepared to use these strongholds for continuous education and training of students, engineers and cooperation teacher.

Overall, the implementation of CAx in I4.0 enhances product development, manufacturing processes, and maintenance activities by leveraging digital technologies, connectivity, and data analytics. These implementations enable increased automation, improved productivity, better decision-making, and enhanced product quality in the context of Industry 4.0. The integration of these tools and systems with emerging technologies such as IoT, AI, and data analytics is instrumental in achieving the vision of a connected, intelligent, and highly efficient manufacturing system.

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REFERENCES

[1] Chryssolouris, G.; Mavrikios, D.; Rentzos, L. The Teaching Factory (2013): A Manufacturing Education Paradigm. *Procedia CIRP*, 57, 44–48

[2] Lizarralde-Dorronsoro, R.; Ganzarain-Epelde, J.; López, C.; Serrano-Lasa, I (2020). An Industry 4.0 maturity model for machine tool companies. *Technol. Forecast. Soc. Chang*, 159, 120-203.

[3] Akyazi T, Goti A, Oyarbide-Zubillaga A, Alberdi E, Carballedo R, Ibeas R, Garcia-Bringas P. (2020): Skills Requirements for the European Machine Tool Sector Emerging from Its Digitalization *Metals*; 10(12):1665. https://doi.org/10.3390/met10121665

[4] Baena F., Guarina A., Moraa J., Sauzab J., Retatc S. (2017): Learning Factory: The Path to Industry 4.0, *Procedia Manufacturing*, 9, 73 – 80

[5] Branca, T.A.; Fornai, B.; Colla, V.; Murri, M.M.; Streppa, E.; Schröder, A.J. (2020). The Challenge of Digitalization in the Steel Sector. *Metals*, 10, 288.

[6] Chen, B.; Wan, J.; Shu, L.; Li, P.; Mukherjee, M.; Yin, B. (2017). Smart factory of Industry 4.0: Key technologies, application case, and challenges. *IEEE Access*, 6, 6505–6519.

[7] Cordero-Guridi, J.-D.-J.; Cuautle-Gutiérrez, L.; Alvarez-Tamayo, R.-I.; Caballero-Morales, S.-O. (2020) Design and Development of a I4.0 Engineering Education Laboratory with Virtual and Digital Technologies Based on ISO/IEC TR 23842-1 Standard Guidelines. *Appl. Sci.*, *12*, 5993. https://doi.org/10.3390/app12125993

[8] Fernandes, F.A.O.; Fuchter Júnior, N.; Daleffe, A.; Fritzen, D.; Alves de Sousa, R.J. (2020) Integrating CAD/CAE/CAM in Engineering Curricula: A Project-Based Learning Approach. *Educ. Sci*, *10*, 125. https://doi.org/10.3390/educsci10050125

[9] Sola-Guirado, R.R., Guerrero-Vacas, G. & Rodríguez-Alabanda, Ó. (2022) Teaching CAD/CAM/CAE tools with project-based learning in virtual distance education. *Educ Inf Technol*, 27, 5051–5073. https://doi.org/10.1007/s10639-021-10826-3

[10] Marković, B., Djurić A. (2022). Education for industry 4.0, situation and challenges – study of the state of secondary school level, *6th International Scientific Conference COMETa 2022*, Jahorina, B&H, Republic of Srpska, pp.496-505.

[11] Milošević, M., Lukić, D., Ostojić, G., Lazarević, M., Antić, A. (2022). Application of cloud-based machine learning in cutting tool condition monitoring. *Journal of Production Engineering*, 25 (1), 20-24.

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