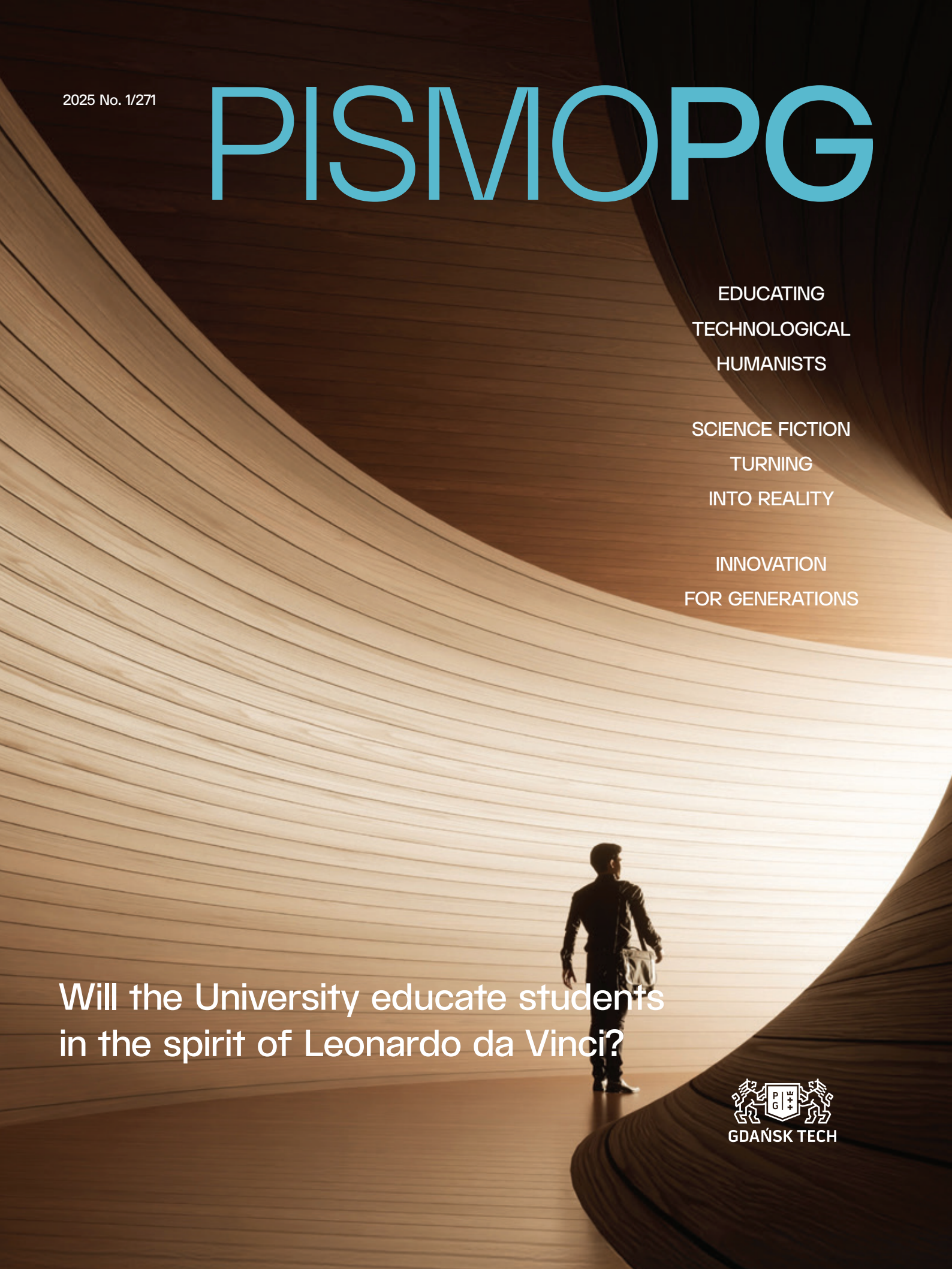
2025 No. 1/271

PISMOPG

EDUCATING
TECHNOLOGICAL
HUMANISTS

SCIENCE FICTION
TURNING
INTO REALITY

INNOVATION
FOR GENERATIONS



Will the University educate students in the spirit of Leonardo da Vinci?

GDAŃSK TECH

THE ENGINEER OF THE FUTURE
Contents

EDUCATING TECHNOLOGICAL HUMANISTS

SCIENCE FICTION TURNING INTO REALITY

INNOVATION FOR GENERATIONS

Authors:

Katarzyna Michałowska – the host of the podcast 'Stacja Zmiana' for eight years, a journalist and editor of podprad.pl; alumna of the Faculty of Electrical and Control Engineering (Electrical Engineering) and the Faculty of Management and Economics (Production Management) at the Gdańsk University of Technology. She completed studies in journalism, psychological counseling (Life and Mission Ministry in Ustroń), and pedagogy (University of Gdańsk). She trains young journalists (Higher School of Social Communication in Gdynia) and organizes conferences. Currently, she conducts classes at the University of Gdańsk (Institute of Media, Journalism and Social Communication), where she introduces the subject of podcasts. She provides training on topics related to emotional intelligence.

Piotr Kallalas – a journalist specializing in medical topics, the education system, and science, who has worked in Pomeranian media for 12 years. For several years, he was associated with 'Dziennik Bałtycki', currently he works in the editorial office of the Trojmiasto.pl portal. In his work, he has long endeavored to popularize science and highlight socially important topics related to prevention, research, and the organization of the healthcare system. He is a recipient of the 'Zdrowe Pióro' award, and has been repeatedly recognized in the 'Medical Journalist of the Year' competition. He holds a Master's degree in Biotechnology – an inter-university program conducted at the Medical University of Gdańsk and the University of Gdańsk.

'Pismo PG' was established in April 1993 and is published with the consent of the Rector of Gdańsk Tech / ISSN 1429-4494 / All Rights Reserved / Contact Address: Gdańsk University of Technology, Editorial Office of 'Pismo PG', Promotion and Press Release Office, Hydromechanics Building, building 11, G. Narutowicza 11/12 Street, 80-233 Gdańsk, tel. (+48) 58 347 17 09, e-mail: pismopg@pg.edu.pl, **pg.edu.pl/pismo**
Content Development and Issue Preparation: Prof. Justyna Kucińska-Lipka, Justyna Borkowska, Iwona Golecka, Paweł Kukla
Translation: Anna Kucharska-Raczunas
Proofreading: Karolina Rogóż-Badzińska
Layout and Graphic Design: Ewa Niziołkiewicz
Photos: Bartosz Bańka, Agata Cymanowska, Renata Dąbrowska, Krzysztof Krzempek, Krzysztof Mystkowski, Edyta Piłat; archives of the International Relations Office

Photo Renata Dąbrowska

DEAR READERS,

It is with great pleasure that I present to you the special edition of 'Pismo PG', the scientific journal of the Gdańsk University of Technology. This publication boasts a rich history, having been a part of the Gdańsk University of Technology for over 30 years now. The first issue dates back to 1993. Initially, it was published as a small newspaper, then evolved into a multi-page publication, and eventually became an e-zine—an electronic magazine accessible online. This current edition marks an entirely new chapter in the history of 'Pismo PG'.

The mission of our university is to serve society. We fulfill this mission not only through researching and implementing solutions but also through the communication of science—by explaining and popularizing it. The new form of 'Pismo PG', published in both Polish and English, reflects this commitment. We are now offering a scientific journal that addresses current and significant aspects of the ever-changing world.

Climate change, complex geopolitics, and the rapid advancement of artificial intelligence are among the problems and challenges faced by the contemporary world, and, by extension, the scientific community. These challenges require not only expertise in formulas and algorithms but also a broad humanistic perspective and ethical reflection.

Thus, the guiding theme of this issue of 'Pismo PG' is the concept of 'the engineer of the future'. What defines such an individual? What skills, tools, and values should they possess? How can we educate individuals with these qualities in a constantly changing world? And finally, is the so-called human tech the answer to the challenges faced by humanity? We explore these and other questions within the pages of this issue.

We will also examine areas where the creative abilities of an engineer could find application—such as those related to the development of artificial intelligence, quantum technologies, or Industry 5.0—as well as projects and implementations in which this humanistic sensitivity is clearly evident.

I am confident that you will find many intriguing topics within the contents we propose. Please feel encouraged to read this edition.

Prof. Krzysztof Wilde
Rector, Gdańsk University of Technology

WILL THE UNIVERSITY **EDUCATE STUDENTS** IN THE SPIRIT OF LEONARDO DA VINCI?

Photo Krzysztof Mystkowski

In an era of artificial intelligence, are algorithms and formulas sufficient for engineers? The Rector of the Gdańsk University of Technology, **Prof. Krzysztof Wilde**, and philosopher **Przemysław Parszutowicz, PhD, DSc, Professor at Gdańsk Tech**, engage in a passionate discussion on redefining the role of engineers in the modern world. Their conversation reveals a fascinating vision of tomorrow's specialist—the humanist engineer, or perhaps even... the philosopher-engineer.

With the ongoing automation and advances in artificial intelligence, engineers are increasingly relieved from repetitive tasks", begins Prof. Krzysztof Wilde, Rector of the Gdańsk University of Technology. "This opens the opportunity to shift the emphasis in engineering work from broadly understood production to the co-creation and shaping of the surrounding reality according to a new vision – using the effective tools now available. Visionaries of the future must understand the world and find their place within it," adds the Rector.

He invokes the image of past masters of bridge engineering who 'meditated by the riverbank' to make their designs combine technical functionality and harmony in the natural environment. In a similar spirit – one also emphasized by Leonardo da Vinci in his concepts of bridges – engineers today must prioritize positive societal outcomes over the economic efficiency of their solutions.

Prof. Przemysław Parszutowicz acknowledges that the idea of an engineer open to the world has long been present in academic discourse, though it often lacks practical implementation in educational practice. "Despite our excellent humanities staff here at Gdańsk Tech, we frequently feel marginalized in the educational process," he admits.

Nonetheless, both speakers agree on the fundamental necessity for a shift in perspective. Prof. Wilde argues that young engineers, entering the world equipped with instruments such as AI-driven tools capable of performing complex tasks, must understand their societal and global roles. They should possess a well-founded canon of moral values to guide ethical and socially responsible actions.

"We do not wish to educate merely outstanding executors of instructions—that is the domain of artificial intelligence," says Prof. Parszutowicz. "We want our graduates to be the ones issuing those instructions, knowing the direction in which that intelligence should evolve," he emphasizes.

Prof. Parszutowicz highlights the unique attributes of the human mind, such as emotional memory and immersion in the world. "Comparing humans to AI is a common misconception. Artificial intelligence exists solely in the realm of data; it does not remember as we do, it does not experience as we do, and crucially—from an educational standpoint—it does not make decisions. Thus, it is incapable of designing a human world, yet that is exactly what our graduates are expected to do—in various spheres," explains the philosopher.

FROM THE ENGINEER OF THE FUTURE TO THE ENGINEER OF THE PRESENT

Later in the discussion, a terminological nuance emerges. Prof. Wilde expresses dissatisfaction with the term 'engineer of the future', favoring instead a focus on actions taken 'here and now' that yield effects within the coming decade or so. In his view, the rapid transformation of the world under the influence of advanced technological tools necessitates an immediate transformation in education.

"The engineer is the one capable of directing development," asserts the Rector of Gdańsk Tech, stressing the need for a 'new consciousness of functioning' among both students and academic staff. In this context, the role of philosophy and the humanities becomes essential so that students, upon graduating, understand the world and find a responsible place within it."

The discussion turns to the division between the exact sciences and the humanities, which, as Prof. Parszutowicz reminds us, has roots in the 19th-century positivism. The speakers argue that this division is entirely outdated in today's scientific landscape. It has created a gap that is difficult to bridge, delegating 'humanists' and 'scientists' to separate realms and often leading to judgments that antagonize the academic community.

Prof. Wilde sees a clear need to educate students who are capable of critical thinking. He then playfully suggests alternative labels—from 'poet-engineer' to 'witcher-engineer.' Prof. Parszutowicz picks up the thought, noting that the terms 'witcher' and 'witch' could serve as excellent Polish equivalents of the term 'philosopher,' as they all relate to knowledge.

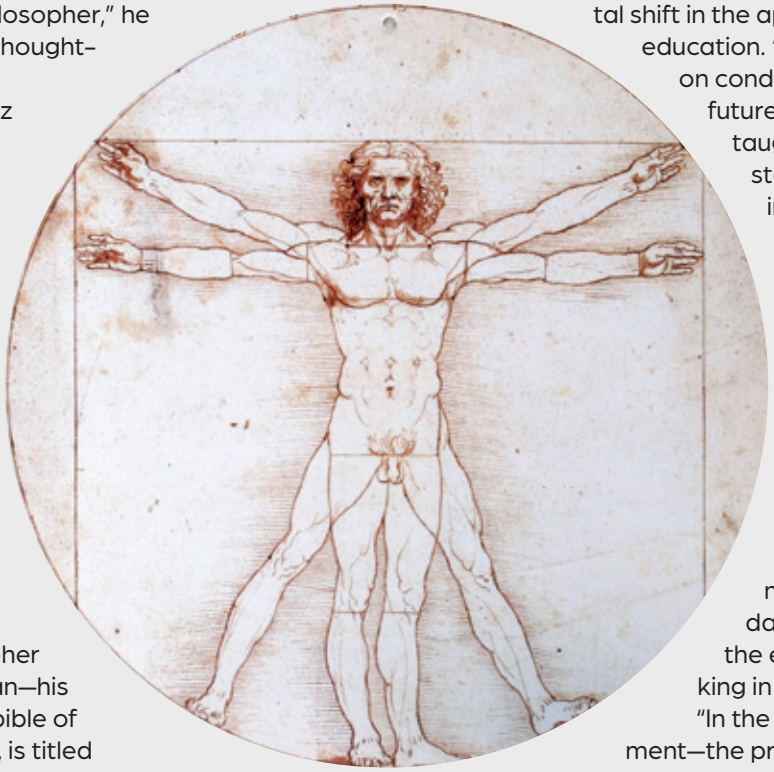
The conclusions drawn from the conversation paint a picture of the engineer of tomorrow (or perhaps rather, the present) as an interdisciplinary specialist, capable of integrating advanced technical knowledge with humanistic wisdom. The participants in the discussion agree that, in the era of technological revolution, it is precisely the human face of engineering that may prove to be crucial in shaping a responsible and sustainable future.

THE PHILOSOPHER-ENGINEER: A NEW VISION FROM THE GDAŃSK UNIVERSITY OF TECHNOLOGY?

"I want the engineer to be a philosopher," dreams Prof. Krzysztof Wilde, the Rector of the Gdańsk University of Technology, in an impassioned exchange with Prof. Przemysław Parszutowicz. Their discus-

sion once again touches on the fundamental shift in understanding the role of the engineer in the digital revolution.

"Is the future of engineering work merely limited to advanced algorithms and precise calculations?" asks Prof. Wilde rhetorically. "The vision of a university graduate goes far beyond the stereotype of a 'screw-tightener'. I dream of a graduate who thinks like a philosopher," he reiterates, pausing thoughtfully.



Prof. Parszutowicz picks up the thread, turning to the etymology of the word 'philosopher.' "Phileo, sophia—it means 'one who loves knowledge'," he explains, emphasizing that in the history of science, the boundaries between philosophy and the exact sciences were fluid. "Newton was both a philosopher and a mathematician—his magnum opus, the bible of classical mechanics, is titled 'Philosophiæ Naturalis Principia Mathematica'—'Mathematical Principles of Natural Philosophy,'" he notes.

Both scholars paint a portrait of a Renaissance engineer—one who combines technical expertise with a profound understanding of the world. "We would like to educate philosophers who are also engineers, and engineers who are also philosophers," declares Prof. Parszutowicz, simultaneously rejecting the stereotypical division between soft and hard skills.

"I believe that we should no longer uphold such divisions. Do you want to be an engineer? Then you must feel for people, understand society, and find your place in the world," echoes Prof. Wilde.

FROM UNDERSTANDING TO EXPERIMENT DESIGNER

The conversation naturally turns to the crucial role of artificial intelligence today. The experts emphasize that engineers must understand the functioning of advanced tools. Prof. Wilde underlines that the central role of the engineer is to control the data on which AI systems are trained. "If we master the data with which we feed modern tools, we can claim to understand artificial intelligence," explains the Rector.

Prof. Parszutowicz proposes a fundamental shift in the approach to engineering education. "Instead of focusing on conducting experiments, future engineers should be taught to design them," he states. "We want to see individuals who design experiments rather than merely execute them—they should be able to define the conditions under which a phenomenon occurs." He stresses that true scientific discoveries arise from conceptualizing conditions, not merely from collecting data. This, he argues, is the essence of critical thinking in its original sense.

"In the past, it was the experiment—the proverbial falling apple—that led a scientist to define the law of universal gravitation," says Prof. Wilde. "That was an observation, learning about the world. Engineers today operate differently. Almost everything we have is now generated digitally," he adds, describing the principle of digital experimentation.

DO YOUNG ENGINEERS WANT PHILOSOPHY?

The conversation raises a key question about student expectations. Is the new generation of engineers ready for philosophical reflection, or are they focused solely on practical tools to enter the job market?

"I believe it largely depends on the educators—the teachers, the mentors. Someone can inspire young people, and someone else can discourage them," responds the philosopher.

"I was once told from the lectern: 'Read a chapter by Tatarkiewicz'," Prof. Wilde recalls with humor,

referring to his student days and philosophy classes, signaling that a discussion on humanism in engineering need not be boring. For Prof. Parszutowicz, a humanist is not just a well-read intellectual, but above all, someone who 'can find common ground between seemingly distant fields'.

Faced with a changing world and the erosion of traditional value systems, the scholars reflect on the university's role in shaping future engineers' attitudes. Prof. Wilde rejects the idea of indoctrination, instead advocating for inspiring reflection on personal value systems.

"If attitudes are to be revealed, we are interested in social and ethical values," the Rector explains. His vision is of a good engineer with 'spiritual richness,' sensitive and empathetic to both the world and people.

Prof. Parszutowicz cites research from the University of Haifa, which indicates that future-valued competencies will include leadership, conflict resolution, adaptability to changing conditions, and empathy. "The skills that will be most valued are those that cannot be replaced by artificial intelligence. Paradoxically, it turns out that the 'competencies of the future' seem to be held by 'people of the past'— mature and experienced individuals. And this raises once again the issue of whether it is possible to teach such competencies to young people," he notes.

The Gdańsk Tech Rector describes important steps taken by the university to foster emotional intelligence in future engineers. He enthusiastically discusses the 'Academy of Leaders' and the initiatives of the Center for Innovative Education, which support the development of soft skills among students and staff. However, he acknowledges that changing mindsets and persuading conservative faculty members to adopt a new approach to student engagement remains a time-consuming challenge.

THE ELITE OF THE FUTURE: AN ENGINEER WITH HEART AND MIND

Both experts agree that, in an era of powerful tools available to engineers, the key factor is their responsibility and ethical approach. "We want our graduates to be a responsible elite, who care about work that will help change the world for the better," emphasizes the Rector of Gdańsk Tech.

In conclusion, Professor Parszutowicz returns to the fundamental question: Engineer – who am I? The philosopher highlights that, in the face of the complex challenges faced by the world, an engineer must combine technical knowledge with a profound understanding of human nature and the surrounding reality.

"One who loves to know," repeats Professor Parszutowicz, emphasizing the key thought. "One who is interested both in how the system of the sky works and how the human being functions," summarizes the philosopher, quoting Kant: The starry sky above me and the moral law within me.

Professor Wilde agrees with this view and paraphrases it to describe the ideal engineer, modeled on the figure of Leonardo da Vinci – 'an engineer of the starry sky and of the moral law!'

■ Katarzyna Michałowska

Photo Krzysztof Mystkowski

The conversation between the Rector of the Gdańsk University of Technology and Prof. Przemysław Parszutowicz is not just an academic debate but, above all, a passionate call for the redefinition of the engineering profession. In a world where technology is becoming increasingly powerful, it is precisely the engineer with heart and mind, the philosopher-engineer, or the humanist engineer who may hold the key to building a better future.

WHAT KIND OF ENGINEERS DOES **INDUSTRY NEED**?

Students seek simplicity and practical training. Lecturers value depth and critical thinking. And the labor market? It continues to redefine its needs. Within this triangle of tensions, engineering education becomes an increasingly complex challenge.

Photo AdobeStock

When it comes to our expectations of young engineers, they are not entirely clear-cut," says **Sławomir Halbryt**, President of the Management Board at Sescom SA. "On the one hand, we care about the engineer possessing technical knowledge; on the other hand, we ask what tasks we actually need them to perform?"

"I believe that during three years of engineering studies, one can acquire a solid technical foundation," Sławomir Halbryt says, reflecting on the current model of engineering education. "However, as entrepreneurs and employers, we do not fully expect a young person to be completely shaped and professionally ready to perform their duties at a technical level. We assume that practical learning is only the beginning, and we are prepared for that. We want graduates to have basic knowledge, but, importantly, we want to see a range of additional qualities in a young engineer, such as curiosity, engagement, or the ability to learn," he explains, outlining the profile of an ideal engineer.

A RETURN TO FIVE-YEAR STUDIES?

The market urgently needs well-prepared engineers, yet the current education system struggles to keep up with this demand. Practice, flexibility, and strong technical fundamentals—these are what employers currently expect.

"I believe a major challenge for effective education of future engineers lies in the Bologna system," begins **Małgorzata Winiarek-Gajewska**, President of the Management Board of NDI Group. "We have undergraduate engineering programs, followed by master's degrees, which relatively few students pursue. In this context, ensuring that a student is both professionally and comprehensively technically prepared is a challenge for curriculum design. Fundamental sciences are extremely important in technical professions because it is essential to understand and describe phenomena, but at the same time preparation for professional practice is also needed. Moreover, soft skills, which are valuable and necessary to develop in young people, must also be addressed—but there is simply not enough time in a three-year bachelor's program."

"A return to five-year studies would support the development of the engineer of the future," Małgorzata Winiarek-Gajewska argues. "However, this does not align with the expectations or needs of either young people or the market. The former wish to gain independence quickly, and the latter—industry—con-

> We want to see a number of additional qualities in a young engineer, such as curiosity, commitment or the ability to learn.

Photo IRO

tinues to experience unsatiated demand for new employees. That is certainly the case in my sector, the construction industry," she explains, pointing to the conflict of interests in her proposed solution. "We ourselves are in a situation where we look for talents already among students. We accept them for internships, hoping to encourage them to remain with the company long-term. As a result, we begin collaborating with individuals who are only broadly prepared for the profession, and we assume significant responsibility for training them to perform their roles in line with the current market standards," she concludes.

"When I look through a candidate's CV, I look at their technical, construction, sanitary, or sales skills," says **Wojciech Falkowski**, President of the Management Board at Ecol-Unicon. "Then I examine their employment history and the teams they have worked in. That is what is important to me, as engineers often take on leadership roles," Wojciech Falkowski notes, describing the recruitment process.

"My ideal engineer of the future has a strong theoretical base, but also practical experience," Falkowski adds, allowing himself a moment of idealization. "During meetings of the University Council, we emphasize that we lack practically-oriented engineers. Currently, many students begin working after completing their bachelor's degrees. Many of them are unwilling to return to formal education, so we are looking for a smart solution. For example, allowing them to follow an individual study path at the master's level while continuing to develop their skills on the job. That's the kind of engineer the market demands," he summarizes, reflecting a shared search for solutions.

A HOLISTIC ENGINEER OR AN EFFICIENT PROJECT IMPLEMENTER?

A young engineer enters the job market in a rapidly changing reality, shaped by environmental challenges and new technologies. Therefore, they should possess a broader range of skills than merely technical knowledge.

"The engineer of the future should be able to view a problem holistically," continues Wojciech Falkowski. "Today we face dynamic changes, including climate-related ones. In management, it is important to 'connect the dots'. When dealing with project implementation, it is not enough to be goal-oriented toward investment execution. Regardless of whe-

Fot. AdobeStock

ther it concerns a new industrial facility, a hydraulic structure, a housing estate, or an airport, one must understand the environmental impact of a given investment. If today we are talking about the engineers of tomorrow, it would be beneficial for them to have a broader perspective on their work. I believe a holistic worldview yields benefits for the employer, the employee, and the planet as a whole," summarizes Wojciech Falkowski.

"We have created the NDI Academy, our own system of training and development programs, focusing on two main areas," states Małgorzata Winiarek-Gajewska. "The first area concerns soft skills—learning how to behave in specific professional situations, such as work organization, teamwork, negotiation, interaction with others, time management, and coping with stressful situations, among others. The second area is practice-based, where we develop our employees' technical knowledge, relying on our own experiences, the practice of more senior colleagues, and case studies—that is, analyzing problems of various kinds and how they were resolved. We base on real-life examples and demonstrate how a given issue was addressed or how a task was organized," explains Winiarek-Gajewska regarding the NDI Academy training program.

"It must be understood that engineers entering the job market have little awareness of the environment in which they will be functioning. University education does not, or only minimally, prepare them for work within a specific market environment," Małgorzata Winiarek-Gajewska emphasizes. "For example, the construction industry today is heavily shaped by the public procurement market, which operates under specific procedures and regulations. Therefore, knowing how to technically carry out a task is insufficient; one must understand how to find their place in this specific contractual environment while ensuring that the project is completed on time, within budget, and in compliance with all formal standards," she explains.

"In my opinion, this is a completely unaddressed area in education. It must be acknowledged that even universities willing to incorporate these aspects into their curricula are unlikely to keep pace with changing market conditions without the assistance and support of industry. We are certainly feeling today that we are taking on a significant share of the professional preparation of our young employees," she emphasizes.

"What truly transforms a young individual into a real engineer is empathy," offers Sławomir Halbryt, presenting another perspective. "It concerns their approach to problem-solving: whether they are capable of resolving issues, managing stress and change, and whether they can employ various solutions and tools to address problems. And if they are unable to solve a problem, they are able to admit it while seeking innovative solutions," comments Sławomir Halbryt.

ENGINEERING COMPETENCIES, APTITUDES, AND ATTITUDES

Engineers work in diverse environments. They may be found in design offices, on construction sites, in industry where they solve practical issues, or in laboratories as innovators.

Experts emphasize the need for close cooperation between universities and business, greater emphasis on practice and social competence, and openness to new challenges such as AI, cultural diversity and climate change.

"Let us note that each of these roles requires slightly different personal traits and predispositions," Sławomir Halbryt introduces a new topic. "In our company, for instance, two extreme personalities emerged—both necessary, yet mutually incomprehensible. The first person was an innovator: an engineer with vivid imagination and great capabilities, capable of connecting various domains of engineering and science. He developed new devices but disregarded legal constraints, believing that innovation should not necessarily comply with existing regulations, especially since we are discovering previously undocumented phenomena. On the other hand, we had another excellent engineer who understood and worked within regulatory boundaries. In his opinion, there was no point in creating a device which could not be marketed legally. Since it failed to meet legal requirements, it could not be approved for release onto the market. Two engineers, two perspectives—completely incompatible," Halbryt illustrates.

"In different roles, we will observe diverse attitudes and aptitudes," he concludes.

"Today, in the engineering profession, hard competencies are not the only aspect of importance; psychological aspects are gaining increasing significance," notes Wojciech Falkowski. "I am referring to the ability to collaborate in a group, to listen, and to communicate effectively with multiple people, as motivating a team is a highly desirable skill. I am not suggesting that an engineer must be a psychologist, but they should understand what matters to the people they work with," Falkowski enumerates.

"Moreover, financial matters are highly significant—an engineer must understand how money flows and how to manage an approved budget. There are also logistical concerns: transportation, procurement, material deliveries, and human resource security. All these aspects are interconnected. In discussing the engineer of the future, we cannot omit the knowledge of artificial intelligence and how to use it wisely," Falkowski continues.

"Given the changing global context, I believe engineers must also prepare for issues related to migration, so that they can work effectively with people from diverse cultures. As an employer, I gladly hire individuals from other countries," Wojciech Falkowski adds.

And what about the engineer's social skills?

"Social skills in engineering education are, in my view, undervalued," says Małgorzata Winiarek-Gajewska. "The ability to discover oneself, one's strengths, areas where one feels confident and effective, should be balanced with technical knowledge. A career path should be developed based on individual aptitudes and competencies," she argues.

"I would not want us to write someone off," adds Sławomir Halbryt. "It may turn out that we are unaware that someone is simply unsuited for a certain type of engineering role. That person should be aware that alternative career or development paths exist. However, we must not make such judgments prematurely; rather, we should use appropriate tools to assess engineering aptitudes," encourages Sławomir Halbryt.

"Educating young people under a uniform curriculum will not yield uniform outcomes. Each individual is profoundly shaped by their own characteristics," elaborates Winiarek-Gajewska. "Everyone is wor-

Photo IRO

> Teaching needs to be remodeled to respond to the needs of the business environment.

king from the same foundation—the same educational program—but each person should independently discover their personal predispositions, which they can further develop in the future. The engineering profession encompasses so many aspects that it allows for the alignment of personal competencies with the actual needs of a project or employer. I believe this approach will enable young people to enter professional life with greater confidence and motivation," she concludes.

"We are increasingly using tools that assess individual aptitudes and, by recognizing strengths, we invest in those who possess them," says Sławomir Halbryt, discussing employee development. "A company must have a clear hierarchy of competencies and tasks within its structure. We need individuals who are quiet and calm yet perform difficult tasks with determination and consistency. These individuals may be invisible in the organization but make significant contributions. Naturally, we notice extroverts more readily because of their spontaneity. We strive to work collaboratively to prevent division and, at the same time, invest in individuals' strengths," he concludes.

IS THE UNIVERSITY CAPABLE OF TRANSFORMING ENGINEERING EDUCATION?

"Universities are struggling with how to balance academic and didactic responsibilities," says Małgorzata Winiarek-Gajewska. "On the one hand, didactics are extremely important, as they constitute the foundation of a university's operation. On the other hand, the evaluation of a university is tied to its scientific activity. Furthermore, the pathway for acquiring funding through various grants and associated projects consumes a significant portion of institutional capacity. There are many conflicting elements, and a university is a complex mechanism. I dream of a model where the student remains at the center of all this. Therefore, I believe that education must be restructured to respond to the needs of the business environment, while also taking into account ongoing changes in societal attitudes. A curriculum tailored to these needs should be developed, supported by targeted supplementary courses or extracurricular clubs, with active participation from industry or potential employers. Additionally, assistance in acquiring competencies related to social skills, psychology, and soft skills is unavoidable—young people seek and need these capacities."

"In addition to a strong foundation in technical knowledge, I would like universities to recognize the importance of engineering attitudes," says Sławomir Halbryt. "This includes the ability to adapt to specific situations, work in teams, collaborate with others, show empathy, solve problems, and manage stress," Sławomir Halbryt lists additional competencies. "Furthermore, the ability to adopt an economic perspective—not that one must know the entire legal framework, but it is important to understand the purpose of law and how it should operate in relation to engineering," he elaborates on the educational needs of engineers.

"Of course, there are individuals who naturally represent certain aptitudes," he adds. "Others may lack

Photo IRO

these qualities and must work on developing them, but today we have many tools to raise early awareness among students about their own capabilities. For instance, Gallup assessments are relatively inexpensive, and universities could offer them to first-year students to encourage reflection on areas requiring development or to identify strengths that can be cultivated throughout their studies," suggests Halbryt.

"If we are to educate individuals prepared to meet the challenges of today's world—and if we succeed in educating engineers who can manage programming, construction, or chemical and physical processes—then we must also consider the social dimension. This means that, courses in ethics and psychology would be beneficial," notes Wojciech Falkowski.

INITIATIVES IN POMERANIA

In Pomerania, concrete actions are being taken to strengthen the potential of young engineers and prepare them for future challenges.

"A relevant example is the nuclear power plant," says Wojciech Falkowski. "We have been planning to build it at the same location for the past forty years. Today, there is a real chance that it may be completed in twelve to fifteen years. But are our universities prepared for this? Are we ready to educate qualified energy specialists? I believe we must urgently ensure the highest quality staff and prepare engineers for future work. We are making incremental progress in this direction—together with the Fahrenheit Union of Universities, the Business for Climate Foundation, and the UN Global Compact Network Poland, we are organizing the Baltic Nuclear Energy Forum, which serves as a platform for exchanging up-to--date knowledge in the field of nuclear energy. As a result, postgraduate and master's programs will be established," Falkowski outlines specific measures.

"I believe that it is the role of technical universities to establish increasingly broad relationships with the business environment and to present companies with specific partnership offers," says Sławomir Halbryt. "I know this is not easy, as entrepreneurs are often very busy and lack the time, resources, or capacity to mentor students. However, I believe that business leaders must become aware of their responsibility to support and foster the development of young people."

"Let us also recognize that our university values sport highly. We are multiple-time Academic Champions of Poland in various disciplines," emphasizes Wojciech Falkowski. "We should continue to support young people also in this area of activity, in addition to their specialized knowledge," he adds.

"Furthermore, I wish to express my belief in the idea of the Fahrenheit Universities, which could realistically enhance the image and prestige of higher education. I am not interested in prestigious rankings, such as the Shanghai Top 500. What matters most is the cooperation among institutions—technical, humanities, and medical ones—aiming to combine the best values, each of them can contribute to a joint university. I believe this collaboration will result in the capacity to educate the engineers of the future," concludes Falkowski.


Photo IRO

A BROADER PERSPECTIVE ON THE EDUCATION SYSTEM

In the ongoing discussion about the future of engineering education, voices are emerging that call for a revision of traditional teaching methods at universities and the exploration of more effective educational models.

"Our higher education institutions are still schools—just of a higher category," says Małgorzata Winiarek-Gajewska. "A teacher comes in and tells us what we are going to do. Instead of a class test, we have a midterm exam; instead of a lesson, we have a lecture," she adds, offering a different perspective.

"Perhaps it is worth looking for other models and tools to see how educational systems that yield concrete results operate," continues Winiarek-Gajewska. "In the Anglo-Saxon system, students engage in constant interaction: they carry out projects, present them, and learn through collaboration. At prestigious universities, there exists a tutorial system, which involves regular meetings in small groups with a tutor. During these sessions, a selected problem—first independently analyzed by the student—is then critically discussed with the academic tutor. This is an exclusive form of education rooted in a different academic tradition, but if we are considering change, it is worth reaching for the best practices," she concludes.

"I encourage university rectors to bring in the best lecturers from Europe and even the world for projects related to energy and climate," says Wojciech Falkowski. "Today's technologies allow us to collaborate with experts from Singapore or California, who can easily deliver lectures to our students remotely. And thanks to the high language proficiency of young engineers, they can benefit from learning directly from top specialists."

A PERSPECTIVE ON THE YOUNGER GENERATION

Changing social realities, the development of technology, and new models of communication are an increasingly prompting reflection regarding the attitudes of the younger generation, not only within academic circles but also in the business sector.

"Young people today are often less confident, at times even timid, and yet they simultaneously may have exaggerated expectations shaped by comparisons imposed by social media," observes Sławomir Halbryt. "I believe they are also subject to intense societal pressure—from both family and peers. They are influenced by many forces. I do not think business leaders need to become psychologists, but I do believe education within companies is necessary to help recognize and understand these mechanisms. It is a lesson worth learning," he adds.

"I have worked in this profession for over thirty years, so I have observed different generations," shares her experience Małgorzata Winiarek-Gajewska. "I see that generational changes are accelerating—today even five years can create a generational gap that leads to significant differences in how rights and responsibilities are perceived and approached," she notes.

Sławomir Halbryt
President of the Management Board, Sescom S.A., Chairman of the Gdańsk Tech University Council

Wojciech Falkowski
President of the Management Board, Ecol-Group Sp. z o.o., Gdańsk Tech University Council

Małgorzata Winiarek-Gajewska
President of the Management Board, NDI Group, Gdańsk Tech University Council

"It seems to me that the university could also play a role in this area," suggests Sławomir Halbryt. "It would be worthwhile to consider a support program for companies focused on raising awareness about generational differences. Of course, universities might argue that this is not their role, and that it falls more under the responsibility of sector organizations, but I believe that synergy between the academic world and business could yield real benefits," he argues.

"I am under the impression that today's youth largely find it difficult to adapt to market conditions," evaluates Wojciech Falkowski. "Unfortunately, the overall level of technical education is declining, and I see no signs of this trend reversing. Young employees frequently change jobs—often, it seems, for trivial reasons. This may indicate a lack of ability to adapt to teamwork. They grew up in the world of video games, they are oriented toward quick goal achievement, and even minor setbacks are perceived as significant failures. I believe this aspect deserves careful attention in the education of engineers," he concludes.

Photo IRO

CHALLENGES AND CHOICES OF A YOUNG ENGINEER

Young engineers face numerous challenges and difficult decisions concerning their career path. Among these are key questions regarding the nature of their work, the stability of employment in the face of technological advancement, and the level of satisfaction derived from their responsibilities.

"I would like to make young people aware that the work of an engineer is far more interesting, diverse, and rewarding than it may commonly seem. Furthermore, I believe it is a profession relatively resistant to obsolescence due to new technologies, and technical education provides a solid foundation for finding one's place in various fields," adds Małgorzata Winiarek-Gajewska.

"Our times will increasingly require career shifts. Many young people ask about the future of their profession and whether long-term planning still makes sense today. Nevertheless, I am convinced that in the construction sector the role of humans will remain irreplaceable for a significant period of time" explains Winiarek-Gajewska.

"I also observe a sense of uncertainty among young individuals, stemming from the multitude of available paths. Paradoxically, this abundance can be a source of unhappiness, generating doubts about one's choices. As a result, young people experience difficulty in making decisions about their future out of fear of disappointment. And after all, one can never truly know whether an alternative choice would have been better," concludes Winiarek-Gajewska.

"I would advise looking at the aspect of life balance," notes Wojciech Falkowski. "We must find moderation in everything: in education, work, family life, and leisure."

"As employers and educators, we should reflect on whether young engineers are happy," he adds. "Many would say that happiness means good income and a high standard of living. However, a more important question is: does their work bring them joy? If so, then we have achieved success. I believe that engineers of the future, doing what they love, working in inspiring teams, and sharing their joy, will achieve significant accomplishments to the benefit of not only themselves," Falkowski concludes.

■ Katarzyna Michałowska

THE KEY TO ENGINEER'S SUCCESS? MODERN EDUCATIONAL METHODS

The future and market challenges compel Polish universities to adopt innovative approaches to engineering education. Today, it is not enough to equip students with broad knowledge and engineering skills; we need graduates capable of creating and understanding artificial intelligence, acting ethically, equipped with critical thinking skills, and well-developed social competencies.

Photo Krzysztof Mystkowski

Today, we are talking about Engineer 4.0, but tomorrow we will be thinking about Engineer 5.0, as the industrial challenges students will face after seven semesters must match market demands.

"We need to stay ahead of 'what is happening on the labour market' to educate people who will enter new realities after 3.5 years of study," says **Mariusz Kaczmarek, PhD, DSc, Eng., Professor at Gdańsk Tech**, Vice-Rector for Education. "If we add second-cycle studies, we have five years to prepare. The Gdańsk University of Technology plans education at least five years ahead, thinking about what should be included in today's study curricula and which competencies should be critical in engineering education."

THE ENGINEERING COMPETENCIES OF THE FUTURE

The key engineering skills of the future go beyond high qualifications, in-depth knowledge, and a practical approach to solving complex problems. Equally important is the ability to tackle the challenges of the green and digital transformations. Future engineers should also possess strong social and ethical skills.

"We are facing the challenge of educating students in modern technologies at various levels, using tools that will be applied responsibly and ethically," states **Prof. Jacek Rumiński, PhD, DSc, Eng.**, Head of the Department of Biomedical Engineering.

At the Gdańsk University of Technology, modern educational methods are employed to meet the needs of developing a broad spectrum of engineering competencies.

"A survey was conducted at the Gdańsk University of Technology, in which over two thousand students participated," says **Joanna Mytnik, PhD, DSc, Professor at Gdańsk Tech,** Director of the Center for Innovative Education. "One of the questions concerned the competencies young people would like to acquire or improve during their studies. The respondents answered as follows: problem-solving (74%), critical thinking (62%), and the ability to learn in third place (55%). For me, as the leader of the CIE, this signals that we need to put even more emphasis on improving teachers' qualifications in designing courses that allow students to develop these skills."

To achieve the ambitious goals of educating engineers of the future, the CIE thinks interdisciplinarily and uses modern educational methods based on research results.

DIGITAL TWIN: A HIGHER LEVEL OF MODELING

In the coming years, future engineers will face organizational challenges across all industries. They will be under pressure to deliver innovative engineering solutions or complex operational models in a short time. A response to this challenge is the digital twin. Such projects allow for visualizing, monitoring, and optimizing operational assets, processes, and resources through various simulations. To think and design in this manner, students must have high digital competencies.

"During the second-cycle courses, we introduce elements related to acquiring broad digital competencies," says Prof. Mariusz Kaczmarek. "This includes not only artificial intelligence but also the ability to use intelligence models in specific fields. For example, we want graduates of the Faculty of Electrical and Control Engineering to be able to implement deep machine learning models for specific needs in their fields," adds Prof. Kaczmarek.

"Large dataset analysis, biomedical engineering, automation, cybernetics, and robotics – we aim to raise our students' digital competencies in every department," continues Prof. Kaczmarek. "This includes the development of digital twins. It's easier to model something, simulate it, and then transfer that experience to real-world objects. This can help any engineer predict potential failures."

To date, digital twin projects at the Gdańsk University of Technology have included scientific applications in architecture (creating a twin of Gdańsk) and medicine (monitoring the risks of pregnancy-related complications).

Once digital twins are created and implemented, they can be used to create self-learning systems capable of optimizing virtually everything – from energy consumption to maintenance scheduling. This leads researchers and engineers into an endless loop of learning and innovation.

Despite the functioning of the digital world, engineers still need to understand, try, touch, tame stress, run experiments, and discover solutions.

USING VR IN EDUCATION AND RESEARCH PROJECTS

The Immersive 3D Visualization Lab (I3DVL) is one of the most technologically advanced places at the Gdańsk University of Technology. It allows engineers to experience firsthand what it is like to

> Technology is evolving rapidly, so lifelong learning is a necessity.

Photo Krzysztof Mystkowski

see and control any device or system created in a virtual world.

"You achieve this by simply wearing lightweight 3D glasses, similar to those used in movie theaters," says **Jacek Lebiedź, PhD, Eng., Professor at Gdańsk Tech**, Head of the Immersive 3D Visualization Lab, and the originator of the I3DVL. "There is no need to wear heavy optoelectronic equipment. Virtual reality is revolutionizing engineering education."

The Immersive 3D Visualization Lab has a wide range of applications and offers approximately 150 virtual spaces, projects, devices, or sceneries. The virtual reality cave is a cube over 3.4 meters high that can instantly transform into a nuclear power plant, a battlefield, the universe, a virtual operating theatre, or a production hall.

"The possibilities are endless," says Prof. Lebiedź. "From learning to operate a milling machine or training a drone operator, through shooting practice, a virtual crime scene investigation, an aerodynamic tunnel, to visualizing chemical structures or 3D medical imaging."

At the I3DVL, imagination is the only limit. The space can also be used for desensitizing or treating various phobias or for rehabilitation, all under the supervision of specialists from relevant scientific fields.

The virtual cave promotes interdisciplinarity. The laboratory collaborates with architects, chemists, physicists, mathematicians, historians, military educators, mechanics, doctors, and psychologists. The results of this cooperation include, among others, an app supporting the treatment of the fear of heights, a game helping children with limited mobility improve their muscle capabilities, a virtual time machine showing the appearance of historical monuments in different eras, and a virtual escape room for mathematics, physics, or chemistry. You can have fun while collecting scientific material and conducting experiments.

TEAM-BASED RESEARCH PROJECTS

Scientific challenges in engineering go hand in hand with the development of skills required to communicate with individuals from various fields. The social skills of future engineers are highly valued by employers.

"Surveys conducted among employers, as well as students, highlight the importance of soft skills," says Prof. Mariusz Kaczmarek. "Working in teams, adapting to interdisciplinary environments to solve complex issues, and learning to lead teams are critical skills. Due to this defined demand, team-based research projects have been introduced for second-cycle courses"

"Our students are excellently prepared in their fields, but once they start working, they realize that the people they collaborate with come from entirely different backgrounds," says **Krzysztof Nowicki, PhD, Eng., Professor at the Gdańsk University of Technology**, and Rector's representative for team-based research projects. "Computer science students often fail to understand the engineering needs, concepts or challenges from other disciplines."

"Currently, at the Gdańsk University of Technology, we are running a project that aims to provide students with opportunities to work in interdisciplinary groups, allowing them to experience firsthand how difficult it can be to convey their knowledge," explains Prof. Nowicki.

While participating in team-based research projects, students engage in processes where they are tasked with verifying a given research hypothesis.

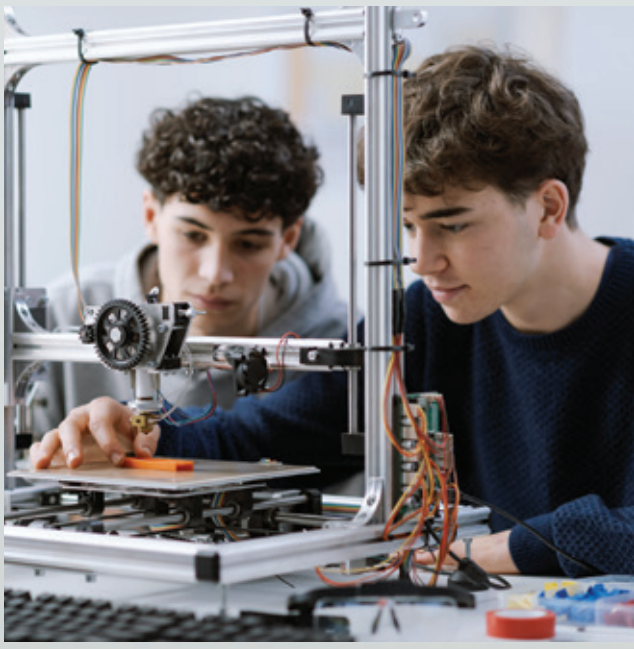
"Each student can choose from hundreds of project topics," says Prof. Nowicki. "There is a wide range of options available, and students can pick a topic more or less related to their specialization. There are no restrictions. A student from the Faculty of Ship Technology can take on a computer science project, and vice versa, as long as they have appropriate competencies to complete the task," explains Prof. Nowicki.

A project selected by a group of students may involve creating a product such as an application or device, conducting necessary research, analyzing results, and preparing presentations and appropriate documentation.

"Students publicly present how they have completed the project," says Prof. Nowicki. "They can receive a Dean's Award, which is several thousand zloty. Additionally, there is a company-sponsored award of several thousand zloty, which is more than enough for a nice dinner," Prof. Nowicki smiles.

A mandatory outcome for projects involving a research hypothesis is a report formatted according to IEEE/Elsevier standards, prepared in English.

Photo AdobeStock



> Avatars and chatbots cannot replace human interaction in teaching.

> Education should foster critical thinking skills.

"Over 10% of the projects result in publications in prestigious global journals," says Prof. Nowicki. "The authors are either students or teams of students and a supervising faculty member."

Team-based research projects foster the development of student skills, enabling them to explore various industries and solve problems. Students learn how to present research, solutions, or applications and how to describe and present them effectively.

The team-based research project initiative encompasses all departments at the Gdańsk University of Technology. Coordinating such numerous project teams requires a smart and individualized approach to education.

INTELLIGENT TEACHING SYSTEMS

Given the growing potential of incorporating artificial intelligence into educational processes, the Gdańsk University of Technology has undertaken several initiatives to develop a tailored version of a chatbot that is personalized and responds to a specific subject.

"The GPTs service allows me to create a personalized version of OpenAI's GPT chat mechanism, which is available to everyone," explains **Piotr Szczuko, PhD, DSc, Eng., Gdańsk Tech Professor** at the Department of Multimedia Systems. "I prepare textual documents, which can also include graphics or selected data and materials relevant to a specific course. I set instructions that the user will not see, such as: 'You are an assistant who helps students learn to develop intelligent algorithms at the master's level in machine learning.' The AI is then designed to act like a teacher, i.e. ask guiding questions and suggest source materials, and the student's task is to draw conclusions independently. The AI assistant evaluates these conclusions and asks further questions."

Once the configuration is complete, the author of the GPTs can share a link leading directly to the personalized service, which acts as a specialized assistant in a particular field.

Photo AdobeStock

"This is a path that educators can follow if they wish," adds Prof. Szczuko. "There are many issues with developing this technology, such as generating incorrect information and the risk of becoming overly dependent on the availability of this service, since GPTs exist today, but they may not be around tomorrow," he concludes.

CAN THE LECTURER BE REPLACED BY AN AVATAR?

The concept of an avatar lecturer may seem tempting at first because, in this model, the university staff member would not need to be physically present in the lecture hall, freeing up time for research.

"This presents many opportunities and risks," says Prof. Jacek Rumiński. "The risks are mainly associated with the improper use of AI tools. It also depends on the nature of the content and the form of delivery. If the lecture is a simple one-way transmission of information, where one person speaks and others passively listen, it could be recorded without AI. However, many lectures are interactive, where instructors assess what areas need further exploration and what can be left out."

"Can innovative methods replace the lecturer? Yes, in some forms of teaching, AI can be used. The advantage of AI in education is the personalization of teaching," concludes Prof. Rumiński.

"The language model (chat) seems to be a perfect example of an intelligent educational AI assistant," says Prof. Piotr Szczuko. "Such an interaction has great advantages: the AI teacher is always available, never fatigued, and possesses vast knowledge. If someone wants to learn something, for example, during a 10-minute train ride, the AI is always available. These are the major advantages of AI. But there are also important drawbacks, such as hallucinations, which are errors in generated responses."

However, the question remains: does a lecturer always know the answer when asked?

"If a lecturer does not know something, they can say, 'Ah! This is an interesting topic, I have not heard about this. Let's meet next week, and I will learn more about it.' AI could be programmed to react in the same way, but unfortunately, all models tend to provide an answer, even when they do not know the topic, and they have problems with admitting that they do not know something. All language models are trained to produce answers that satisfy the user," says Prof. Szczuko. Such answers should be written in a nice language, suitably long and in bullet points, even if they are not necessarily correct or logical – adds Prof. Szczuko.

Looking at the avatar lecturer, the student will experience firsthand a phenomenon known from the 1970s, called the uncanny valley.

"The face and eyes that imitate human ones make people feel disgusted, and this blocks the possibility of accepting the content", says Prof. Szczuko. "Another thing is that natural speech engages our attention differently. A speech synthesizer is tedious, not to mention the boring content generated by the language model itself, which is Chat GPT."

"Let's remember that studies are also a process of maturing", says Prof. Jacek Rumiński. "Studies are not just for learning some content. It is a process of interacting with other students and teachers. Additionally, teachers and mentors are responsible for developing the best proposal from the viewpoint of experts. And sometimes it is contrary to what

Photo Krzysztof Mystkowski

> Education should foster critical thinking skills.

young people say, to make things easy. This does not mean that everything will be useful to everyone within the framework of the education program. Let us remember that it is also about intellectual training. After all, it is never the case that all content will be useful to someone, but this content constitutes a certain basis for self-development, for studying. And here, I believe that the existing tools in the field of distance learning techniques, or materials in electronic form, or other modern interactive forms, are great additional materials," elaborates on the subject Prof. Rumiński. "To sum up, I believe that some lectures can be successfully replaced by artificial intelligence methods, while a number of other forms will be irreplaceable. And this results from human nature and values related to interpersonal contacts, which also affect aspects of motivation and intellectual maturity", concludes Prof. Rumiński.

TEACHER TRAINING

"We must abandon the concept that the teacher is the source of knowledge," says Prof. Krzysztof Nowicki. "That era is over. The teacher should now motivate and explain why things are the way they are, how they work. However, the detailed knowledge that thirty years ago formed the foundation of education is no longer the role of the university. The process of structuring knowledge is now the teacher's task," says Prof. Nowicki.

A few years ago, the Center for Innovative Education (CIE) was established at the Gdańsk University of Technology with the aim of fostering innovation in engineering education by designing actions based on reports and global trends in higher education.

"Teachers have specialized knowledge and experience, and the CIE offers them opportunities for professional development in methodological and didactic competencies, including in the area of generative artificial intelligence," says Prof. Joanna Mytnik. "Our work is based on modern teaching methodologies, the latest neuroscience knowledge, labor market analyses, and sensitivity to the needs of others, ensuring that educators design educational processes as part of a broader learning ecosystem that is closely connected to the dynamic world beyond the university."

The Center continually offers a wide range of workshops where academic staff from all faculties and teaching centers meet. Apart from teaching methodologies, teachers have the chance to learn about the specifics of how other faculties operate, which fosters exchange of experiences and good practices, mutual inspiration, and most importantly,

Mariusz Kaczmarek, PhD, DSc, Eng., Professor at Gdańsk Tech

Vice-Rector for Education

Prof. Jacek Rumiński, PhD, DSc, Eng.

Faculty of Electronics, Telecommunications and Informatics, Chairman of the AI Bay Artificial Intelligence Club at Gdańsk Tech

Joanna Mytnik, PhD, DSc, Professor at Gdańsk Tech

Director of the Center for Innovative Education, Gdańsk Tech

Jacek Lebiedź, PhD, Eng., Professor at Gdańsk Tech

Faculty of Electronics, Telecommunications and Informatics

Krzysztof Nowicki, PhD, Eng., Professor at Gdańsk Tech

Rector's representative for team-based research projects, Faculty of Electronics, Telecommunications and Informatics

Piotr Szczuko, PhD, DSc, Eng., Professor at Gdańsk Tech

Department of Multimedia Systems, Faculty of Electronics, Telecommunications and Informatics

Photo AdobeStock

building relationships, which helps prevent professional burnout.

The Center for Innovative Education at the Gdańsk University of Technology was established on March 1, 2021 by His Magnificence the Rector of the Gdańsk University of Technology, Professor Krzysztof Wilde.

"The idea of creating a new unit is the beginning of a process aimed at achieving a real change in education," says Prof. Joanna Mytnik. "Our goal is to support teachers in reflective design of active learning environments, which means both reliable teaching methodologies and educators' proficiency in the latest technologies for academic teaching (including VR and genAI), as well as building a community of academic teachers."

"At the CIE, we focus on communication, cooperation, creation, critical thinking and change incorporation competencies, as well as mindfulness and well-being, and supporting students in this process,"says Prof. Mytnik.

"By offering teachers various types of development and appreciation programs, didactic conferences, training, coaching, innovation competitions, debates, project groups, methodological hubs or cooperation networks (e.g. a network of AI methodology or distance learning ambassadors), we provide the opportunity to constantly improve their competences," emphasizes Prof. Mytnik. "Teachers who have a need for continuous learning are prepared to support young people in this process, prepare them to develop proactive attitudes and take responsibility for the process of their development," she sums up.

"AI does not motivate," says Prof. Krzysztof Nowicki. "AI provides knowledge. This is crucial when considering AI's future role in education. We will use it, and we will develop it, but AI will not replace the authority of the teacher or the desire to follow them," concludes Prof. Nowicki.

"Lifelong learning is incredibly important today," says Prof. Jacek Rumiński. "If I think that completing my studies marks the end of my education, I will likely face limited opportunities in the job market. Therefore, promoting education and research is essential," adds Prof. Rumiński.

■ Katarzyna Michałowska

INDUSTRY 5.0 – THE ENGINEER AT THE CENTER OF THE REVOLUTION

Photo AdobeStock

The fifth technological revolution represents a step toward the humanization of the ongoing digital changes that have driven industrial development in recent years. At its core is the engineer, whose work is aimed at promoting social and environmental responsibility. Graduates of the new program – Industry 5.0 Technologies – are to be prepared for such tasks. What challenges, as well as risks, does the next industrial revolution entail?

Does the emergence of Industry 5.0 bear the hallmarks of a revolution, or is it a more subtle process based on the evolution of the assumptions of Industry 4.0? Although we do not yet observe a spectacular transformation of the urban landscape, as was characteristic of the second industrial revolution, we can still find its traces, for instance, when visiting the historic part of Łódź, which is full of remnants of the former textile industry power. The residents of the 'Polish Manchester' living at the turn of the 19th and 20th centuries were able to almost touch these changes. They could witness the first electric trams, feel the smoke rising from factory chimneys, hear the sounds of thousands of textile machines, and ultimately be employed in the newly emerging professions.

"IN INDUSTRY 5.0, HUMANS ARE PUSHED TO THE FOREFRONT"

The contemporary industrial revolutions, which we experience today, are equally spectacular in terms of their impact on humanity, though less conspicuous – they focus on optimizing our daily lives, providing access to information, streamlining industrial processes, and enhancing productivity and efficiency – all on an unimaginable scale. The Fourth Industrial Revolution, also known as the digital revolution, provided us with tools to manage

> This time, in Industry 5.0, the human being is put in the first place and it is the human who is supposed to direct and manage everything. It is the human who is supposed to make decisions, weld everything together and be in the middle of the changes taking place.

Laboratory of Hydraulics, the building of the Eco-Innovation Centre/ Photo. Krzysztof Mystkowski

data, automate processes, and, thanks to artificial intelligence, magnify these possibilities. However, we have reached a point where the assumptions for further development require correction.

"We have not yet achieved all the goals of the Fourth Industrial Revolution. However, a modification is currently underway, adjusting its assumptions. The last revolution was related to artificial intelligence and involved several elements focusing mainly on automation, informatization, and system integration. In the process, however, the human element was somewhat overlooked. This time, in Industry 5.0, the human being is placed at the forefront, and it is the human who is to lead and manage everything. It is the human who will make decisions, integrate everything, and be at the center of the ongoing changes," explains **Prof. Piotr Jasiński, PhD, DSc, Eng.**, from the Department of Functional Materials Engineering at the Faculty of Electronics, Telecommunications and Informatics.

We no longer speak of technology replacing humans, but of solutions that are utilized by humans to optimize industrial processes or increase effectiveness and safety. Moreover, the approach will be more personalized, where both the engineer, who sets the course of action, and the customer, as the recipient of customized products or services, are paramount.

"A good example is ChatGPT. Everyone uses it, often obtaining questionable-quality contents. However, if we know how to cooperate with it, how to use it correctly as a tool, we can work very effectively with it. This is the difference between Industry 4.0 and Industry 5.0. The experience of humans surpasses artificial intelligence. Similarly, for example, during recent floods, the combination of expert knowledge and meteorological models allowed to obtain complete information about the scale of the threat," points out **Jacek Ryl, PhD, DSc, Eng., Professor at Gdańsk Tech**, from the Institute of Nanotechnology and Materials Engineering at the Faculty of Applied Physics and Mathematics.

"TO LEAVE BEHIND A WORLD NO WORSE THAN THE ONE WE FOUND"

Another pillar of the 5.0 revolution emphasizes social and environmental responsibility. With such powerful tools in our hands, we should direct our efforts toward mitigating the negative processes of

> Anticipating possible emergencies and preparing for their occurrence requires the application of the knowledge of predictive analytics, the introduction of organizational flexibility, and skills in the field of change management.

PhotoAdobeStock

the ongoing degradation of our planet caused by the excessive exploitation of resources.

"This goal includes, among other things, reducing gas and waste emission, as well as optimizing the use and recycling of natural resources, which makes production processes less harmful to the planet. This direction is a consequence of the observed and increasing environmental changes and threats, which we can partially counteract through modern technologies. This is particularly important as we have come to appreciate that a green, friendly environment and the natural world are integral parts of our well-being," emphasizes Grażyna Musiatowicz-Podbiał, PhD, from the Department of Informatics in Management at the Faculty of Management and Economics.

"By using tools associated with artificial intelligence, we can easily model the impact on environmental aspects and properly optimize technological processes. It is important to leave behind a world no worse than the one we found," adds Prof Jacek Ryl.

"ANTICIPATING CRISIS SITUATIONS"

The third pillar of the 5.0 revolution concerns enhancing organizational resilience to the changing world and surrounding threats, including development of action plans in response to geopolitical changes, epidemics, or natural disasters.

"It turned out that economies and companies that had already invested in the technologies defined in the previous revolution, namely in the Industry 4.0 concept, coped better with fluctuations such as the COVID-19 pandemic or warfare," notes Grażyna Musiatowicz-Podbiał, PhD. "We do not have to go far for examples. In the neighbouring Ukraine, state institutions had to quickly adapt to functioning smoothly alongside the ongoing war. This was largely achieved through the use of digital technologies, which allowed not only the remote servicing of citizens but also the scaling of solutions and services. It is also worth noting that in many countries, including Poland, the epidemic-driven lockdown significantly

The **Industry 5.0** Technologies program is implemented at the Faculties of Applied Physics and Mathematics, and Electronics, Telecommunications and Informatics.

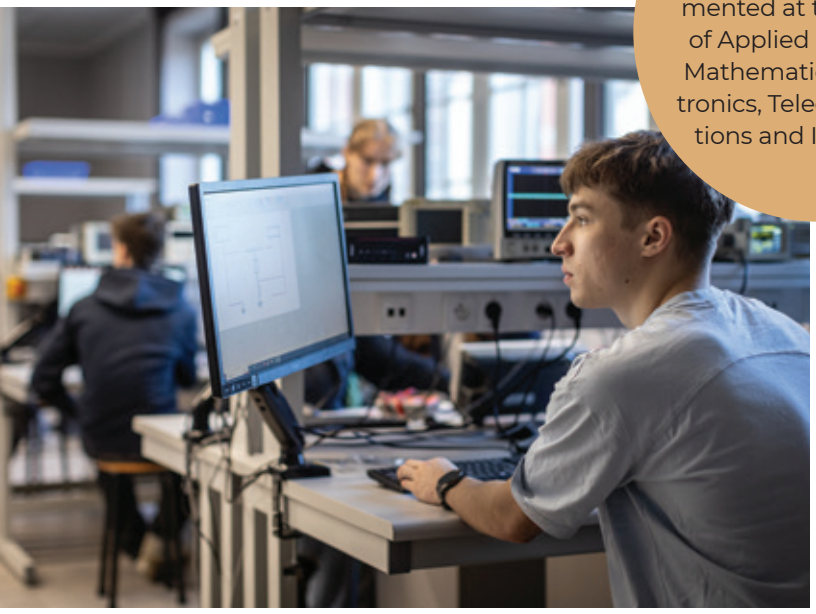


Photo Krzysztof Mystkowski

accelerated the digitalization of public services. Predicting possible crisis situations and planning actions for when they occur requires the use of predictive analytics, organizational flexibility, and change management skills."

"WE HAVE PROPOSED AN INNOVATIVE SOLUTION"

This year, the Gdańsk University of Technology has launched a new program – Industry 5.0 Technologies, offered by the Faculties of Applied Physics and Mathematics, and Electronics, Telecommunications, and Informatics, which will enable graduates to find their place in the new reality of the fifth industrial revolution.

"This is a significant challenge also in the context of the labor market. It is changing dynamically, as is the demand for engineers' work. We need to permanently improve and reform our educational model, which still relies on the 19th-century Prussian model. Therefore, we proposed a teaching method based on project-based learning as an alternative. This model, successfully used at the world's most prestigious universities, is focused on acquiring qualifications through the student's independent work on solving a real problem, in this case an industrial one. The student must find the necessary knowledge with the help of a teacher who acts as a mentor, a guide. Efficient, self-directed learning while solving research and technical issues allows students to address the problem and helps them adapt to the technological changes that will come in five or ten years," outlines Prof. Jacek Ryl.

What distinguishes this new program is the emphasis on the practical dimension of education.

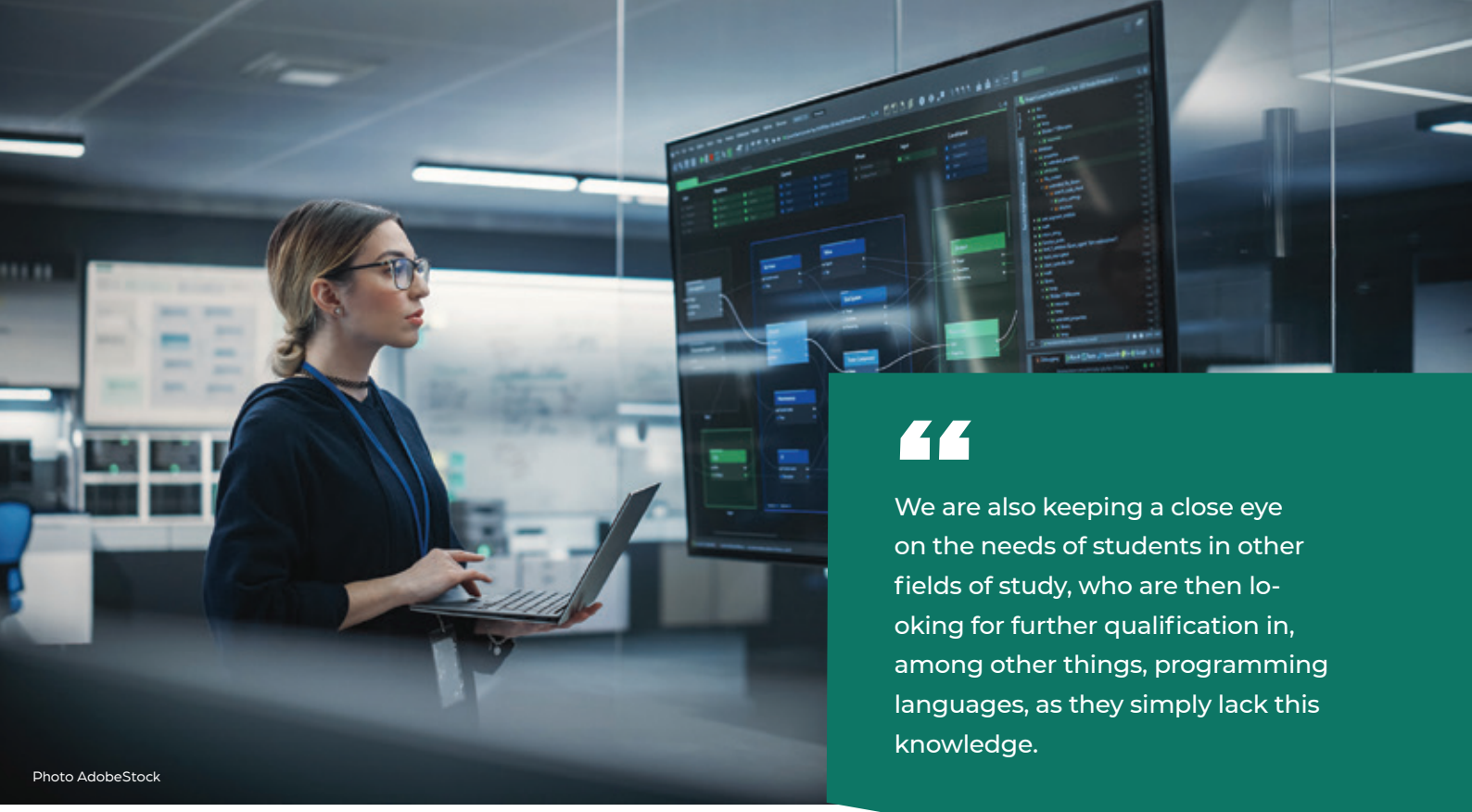


Photo AdobeStock

> We are also keeping a close eye on the needs of students in other fields of study, who are then looking for further qualification in, among other things, programming languages, as they simply lack this knowledge.

The curriculum includes 500 hours of project-based classes, where students will tackle technological problems. In total, students will complete 1500 hours of practical training during the entire course of their studies.

"Additionally, we have proposed a rather innovative solution – we want to run two semesters in such a way that, in each semester, ten weeks are devoted to normal learning, and for five weeks, the focus will be exclusively on a technological project. There are no other distractions, and the student focuses solely on the assigned problem," adds Prof. Jacek Ryl.

"A STRONG EMPHASIS ON PROGRAMMING"

The course includes two specializations. In the case of the Internet of Things Engineering, the curriculum covers programming, data transmission technologies, sensors, and the use of artificial intelligence for these purposes. The originators of the course indicate that the second specialization – Measurement Engineering in Industrial Systems – is more process-oriented.

"We place a strong emphasis on programming in every semester – we start with the basics in the C language, through scripting languages, to the use of artificial intelligence algorithms. We expand this by observing market demand and trends. Our graduates will be able to prove themselves wherever large amounts of data are produced, where there is a need for data integration and transmission – whether wired or wirelessly, and then process them, including using artificial intelligence tools," explains Prof. Piotr Jasiński.

The ubiquitous use of technology in various industries and the need for intelligent solution management mean that engineers will find employment in various sectors, including high-tech industries, heavy industries, as well as chemical and energy sectors.

"The knowledge our students will gain during their studies will allow them to adapt to many industrial sectors. Graduates will be able to design and oversee virtual and physical control of processes, devices, their optimization, and automation. An engineer, especially one working in a small- or medium-sized company, should possess universal competencies, be aware of technological development, and have the capability of implementing new solutions in their company. We are also closely monitoring the needs of students from other study programs, as they later seek further qualification, especially in programming languages, because they simply lack this knowledge," emphasizes Prof.Jacek Ryl.

Industry 5.0 revolution brings both opportunities and challenges that engineers must strive to keep

Prof. Piotr Jasiński, PhD, DSc, Eng.
Department of Functional Materials Engineering, Faculty of Electronics, Telecommunications and Informatics

Jacek Ryl, PhD, DSc, Eng., Professor at Gdańsk Tech
Institute of Nanotechnology and Materials Engineering, Faculty of Applied Physics and Mathematics

Grażyna Musiatowicz-Podbiał, PhD
Department of Informatics in Management, Faculty of Management and Economics

up with. Considering how rapidly the technological progress in artificial intelligence has accelerated in recent years, it is reasonable to predict that we will soon face the need for further adjustments to our assumptions, the creation of a new strategy, and, inevitably, the emergence of another revolution. The originators of the new study program are preparing future graduates to find their place in the ever-changing industry and tackle challenges that will arise.

"We would like to prepare students for creatively solving complex problems, not only current ones but also those that they will face in the future. Social problems, by nature, are extremely complicated because they require understanding not only their root causes but also the broader impact that the proposed solutions will have on society and the environment. Therefore, on the one hand, we want to teach empathetic understanding of the complexity of challenges, and, on the other hand, to show the possibilities offered by the technologies at hand. Importantly, it is not about using specific technologies, as these change rapidly. In a few years, our graduates will most likely have to search for and use other technologies and tools. It is important that they are able to assess their usefulness and select the optimal set for solving the problem. We want them to be prepared for constant solution-seeking and lifelong learning. They should possess the ability to adapt to changing roles, situations, and needs," notes Grażyna Musiatowicz-Podbiał, PhD.

TAMING THE MONSTER

In the history of humanity, every technological revolution, apart from the clear benefits that drive action and lead to the search for even better solutions, is also accompanied by fears, anxieties, and threats. This was the case in the 19th century when the industrial revolution brought progress, and, at the same time, worker exploitation and hazardous conditions in factories. What dangers will engineers in Industry 5.0 face?

"Technological development greatly facilitates our lives, accelerates the flow of information, increases process efficiency, and simplifies the production and delivery of goods and services better tailored to our needs. However, it can also lead to a range of negative, even threatening, side effects," warns Grażyna Musiatowicz-Podbiał, PhD. "We must sensitize our graduates to these aspects. It is important that they remember that in robotizing and automating processes, often on a large scale, they should ensure the significant role of intelligent, creative humans, especially in making often non-obvious decisions. We cannot leave the development of technology unchecked, especially where its effects will impact people."

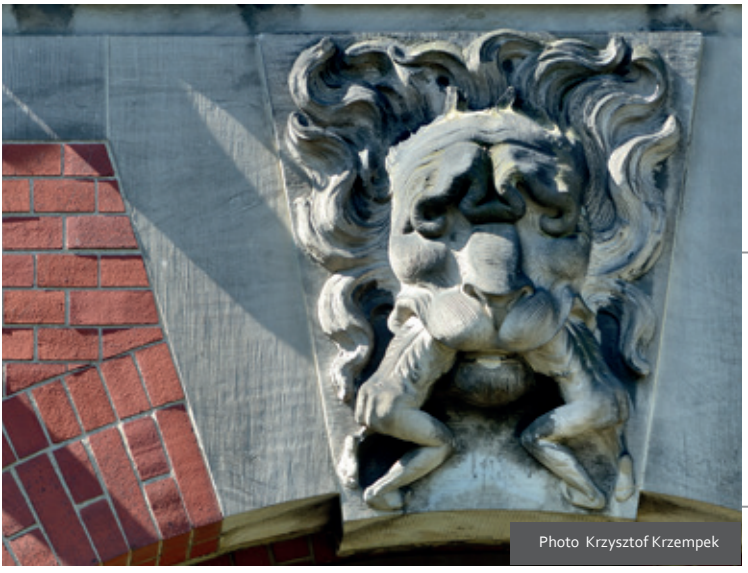


Photo Krzysztof Krzempek

The need for technological control is also symbolized by one of the grotesques on the facade of the Main Building of the Gdańsk University of Technology – representing progress that escapes control and ultimately devours the world. It is our responsibility to tame the monster but also to domesticate it by creating safeguards and educating society.

■ Piotr Kallalas

QUANTUM TECHNOLOGY: A LEAP INTO THE FUTURE

The Gdańsk University of Technology is currently undertaking intensive efforts to acquire a quantum computer. Although the technology itself is still in the developmental phase, all indications are that a computational revolution is imminent, and it may be the scientific community that will benefit the most from it.

Photo AdobeStock

It has been two years since the opening of the Competence Center STOS, located underground on the slopes of the Szubieniczna Góra (Gallows Hill), where the Kraken supercomputer was presented. This advanced system has significantly enhanced computational power, enabling scientists from a wide array of disciplines to conduct research and simulations: from nuclear energy, through environmental protection, to medicine and pharmacology, which is where modeling based on vast amounts of data is required. In other words, the tool facilitates, and in some cases enables, the creation of new technologies and solutions.

However, the world does not tolerate stagnation, and after two years, discussions are intensifying about plans to advance to the next level of computational power, which will be realized through the installation of a quantum computer. This represents a leap into the future—moving away from the traditional bit-based system in favor of a technology that, although still in its developmental stage, theoretically promises enormous advantages.

"It is obvious that supercomputers are continuously being improved. In addition to faster classical processors, systems with graphic processing units, which are more suited for artificial intelligence algorithms, are also available. However, processing complex algorithms on vast data sets results in exponential computational complexity, where computation times grow exponentially as the size of the data increases. This limits the potential of such analysis. Therefore, it is better to focus on computers where computation time increases linearly in such cases. A quantum computer can provide this, and this is one of its greatest advantages," emphasizes **Prof. Henryk Krawczyk, PhD, DSc, Eng.**, the project's originator and manager.

THINKING ABOUT THE FUTURE

This does not mean that supercomputers are obsolete or irrelevant; rather, it is the next stage in the development of computational capabilities of the Competence Center STOS in Gdańsk — both technologies are intended to complement each other.

"Thinking about the future forces us to develop technology that meets the increasing demands for computational and energy power. This applies not only to science but also to many practical problems solved through collaboration between academic institutions and both Polish and international companies. In order to meet these challenges, the Gdańsk University of Technology has been working on the development of supercomputing for 30 years now. What we observe is similar to the construction of roads. Many highways are built to alleviate traffic congestion, but over time, new arteries become insufficient. Thus, we need increasingly greater computational power, or in other words, ever faster supercomputers," adds Prof. Henryk Krawczyk.

Quantum technology, which is still in its early stages, will not reach the Pomeranian region without the infrastructure developed on the slopes of the Szubieniczna Góra. At the Competence Center STOS, empty chambers were specifically left in the server room to provide the necessary conditions for the operation of a quantum computer. However, this is no simple task—qubits, the basis of 'future technology', are highly sensitive to disturbances and function best in low temperatures, or rather in extremely low temperatures. Only under such conditions can synergy be achieved.

"This progress not only lays the foundation for future hardware but also emphasizes the significant cooperation between a quantum computer and a

Competence Center STOS / Photo Krzysztof Mystkowski

> However, the world does not tolerate stagnation, and after two years, discussions are intensifying about plans to advance to the next level of computational power, which will be realized through the installation of a quantum computer.

> At the Competence Center STOS, empty chambers were specifically left in the server room to provide the necessary conditions for the operation of a quantum computer.

Photo Bartosz Bańka

supercomputer, particularly in data preparation and transmission. This is the implementation of a computational hybrid, where the supercomputer works in tandem with the quantum computer. Quantum computers must be properly shielded and, most importantly, maintained at extremely low temperatures, close to absolute zero. This is crucial because quantum computers are very susceptible to disturbances caused by higher temperatures and other interactions that can destroy delicate entangled states. Current development is focused on combining multiple physical qubits to create a single logical qubit that is resistant to such disturbances," explains **Prof. Józef Sienkiewicz, PhD, DSc, Eng**., Vice-Rector for Partnerships.

"DIVING INTO THE MICROSCALE"

Theoretical assumptions suggest that replacing the binary system with a qubit-based system capable of achieving multiple states will revolutionize computational capabilities on a massive scale.

"In this case, processing involves binary operations carried out by qubits—quantum bits. Instead of analyzing a single binary string, all possible combinations are considered. This allows various operations on qubits to be performed in parallel," explains Prof. Henryk Krawczyk.

"Having a quantum computer will significantly accelerate scientific development in Gdańsk, Pomerania, and the entire country. The change entails replacing classical binary systems with quantum systems. In classical computers, information is managed using devices such as transistors. In superconducting quantum computers, the equivalents are Josephson junctions. We are delving into the microscale, where electrons, photons, and atoms transmit quantum information," adds Prof. Józef Sienkiewicz.

RISING EXPECTATIONS AMID PROGRESS

It is important to note that we are still discussing technologies that are under development. While expectations are high, we are at a rather exciting moment. We understand the potential, but the technology remains complex and susceptible to disturbances, meaning we are still awaiting the first steps of this revolution and its practical applications.

There are also technical challenges ahead. Quantum computers are more energy-intensive, leading some institutions to plan for the construction of micro-nuclear power plants at their computing centers. Additionally, as experts point out, data storage itself is more costly. Despite these obstacles, quantum technology is already being gradually implemented.

quantum physics are a niche phenomenon. In practice, we know that the Swiss banking system employs such security in communications, and Toshiba is working on commercial implementations. However, given the advancements in this field, we can expect the market to grow. Quantum cryptography holds a significant advantage over classical cryptography—the very design of protocols ensures that the laws of physics prevent any breach of security. Any disturbance is immediately detectable. In recent years, device-independent cryptography has also been developed, allowing secure communication even if we do not trust the devices we use. For example, we can purchase a cryptographic system from Russia, a country we do not trust, but the technology guarantees that the device itself cannot deceive us," explains **Piotr Mironowicz, PhD, DSc, Eng.,** Gdańsk Tech Professor at the Department of Algorithms and Systems Modelling.

DOES TECHNOLOGY POSE A THREAT?

Currently, due to the costs and the need to invest in advanced technical solutions, only a few institutions can afford to begin work in this area. But what if the technology falls into the wrong hands? What threats do quantum computers pose to cybersecurity?

"Indeed, this raises certain risks. Classical systems rely on the difficulty of factorizing numbers. In other words, the security of classical cryptography is based on the fact that certain calculations are extremely costly and time-consuming, and no one will invest enough resources to break those ciphers. With quantum technology, this will not only be easy but incredibly fast. Therefore, the advent of quantum technology will make security based on classical systems obsolete. In today's world, this is critical, as practically everything we do requires secure communication—from banking issues, the most obvious example, to conversations, eavesdropping concerns, and the Internet of Things. We want communication between our devices, such as those in our homes, to be secure from third-party interference," states Prof. Piotr Mironowicz.

Experts, however, remain calm about the future, emphasizing that these processes will run in parallel—security-related solutions will be developed at the same time.

> The potential for quantum computing could also prove highly effective in the security sector, especially for monitoring crisis situations, developing solutions, and optimizing procedures in response to threats.

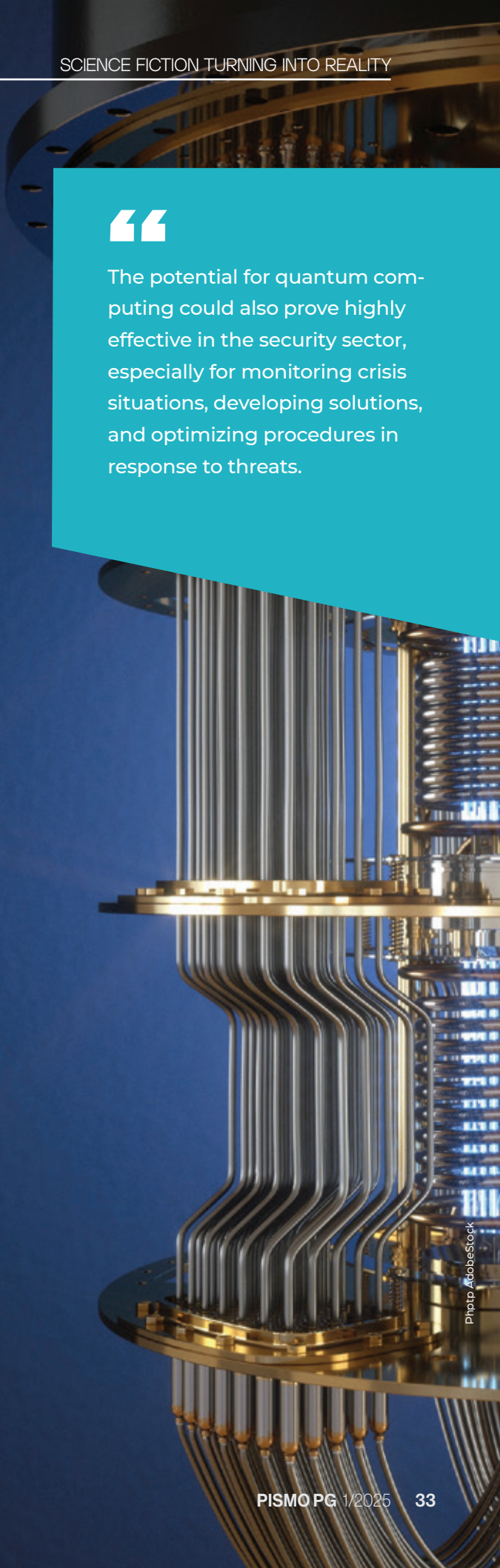


Photo AdobeStock

Prof. Henryk Krawczyk, PhD, DSc, Eng.

CAISE Project Leader, Rector of Gdańsk Tech 2008–2016

Prof. Józef Sienkiewicz, PhD, DSc, Eng.

Vice-Rector for Partnerships, Division of Theoretical Physics and Quantum Information, Faculty of Applied Physics and Mathematics

Piotr Mironowicz, PhD, DSc, Eng., Professor at Gdańsk Tech

Department of Algorithms and Systems Modelling, Faculty of Electronics, Telecommunications and Informatics

COMPUTATIONS WILL TAKE SECONDS, NOT DAYS

It is difficult to conceptualize the computational power of quantum technologies without concrete examples. It is, therefore, worth reaching to fields like biotechnology and pharmaceuticals, where the modeling process involves thousands of particles, such as when developing new compounds or studying the interactions of active substances and biochemical processes.

"All biology deals with hundreds of thousands of atoms and the interactions between them, so modeling such systems is incredibly complex, especially using classical computers. Just consider analyzing a protein made of thousands of amino acids. In any foreseeable future, we will not be able to create such models with standard computing power. However, quantum computers can provide such capabilities, and in my opinion, this is a 10–15 year perspective. This is very forward-looking, as it could significantly reduce laboratory work in favor of quantum computational modeling," adds Prof. Piotr Mironowicz.

However, we are already witnessing the effects of increased computational power. The installation of a supercomputer has significantly reduced the time needed for research teams to complete their work.

"Just imagine modeling a virus's interaction with a protein. Not long ago, modeling such a reaction took at least a year. Thanks to modifications of traditional algorithms, calculations now take one or two days, which is about a thousand times faster. In the case of a quantum computer, the time for calculating complex reactions will be measured in seconds at most. This will undoubtedly increase the possibilities for conducting research and, consequently, improve the efficiency of scientists' work," adds Prof. Henryk Krawczyk.

Biotechnological and pharmaceutical sciences are just one of the areas where quantum technology could prove effective.

"Quantum technology will also be of great significance for ecology, improving energy processing efficiency, and optimizing energy generation and conversion processes. We will be able to model various types of processes and propose new solutions. Additionally, quantum computers will be used in economics for market analysis and fraud detection to minimize risks and increase profits," concludes Prof. Piotr Mironowicz.

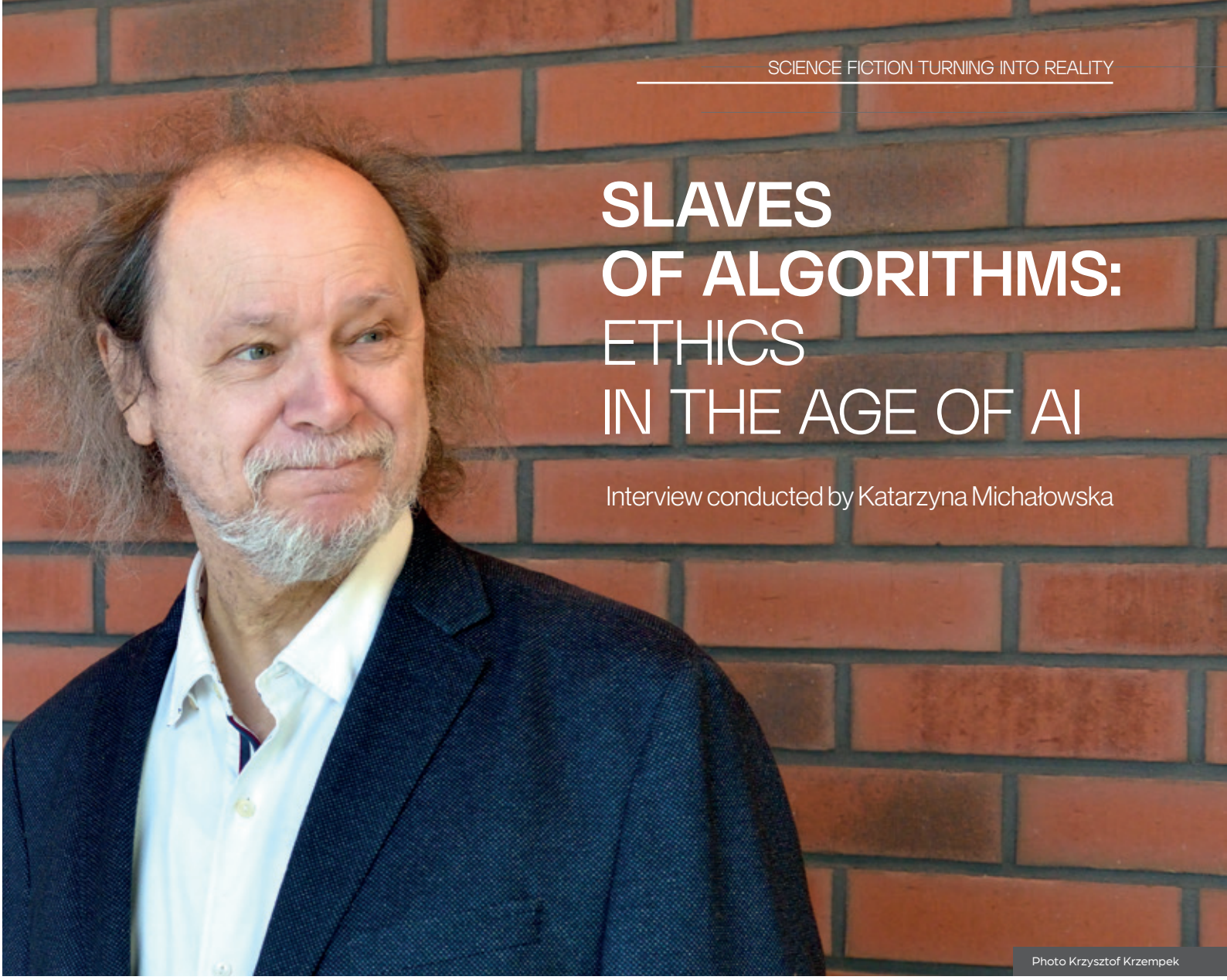
The potential for quantum computing could also prove highly effective in the security sector, especially for monitoring crisis situations, developing solutions, and optimizing procedures in response to threats. Skillful use of the technology would support the management processes where rapid and precise decisions are needed based on numerous variables. This represents a significant opportunity for our region.

"There are ideas aimed at creating a digital representation of the energy network in regions like Pomerania. Such a digital model would allow the simulation of dangerous phenomena and quick identification of solutions based on scenarios developed using a quantum computer. Although the above undertakings are challenging, we remain optimistic about the potential of quantum computing," says Prof. Józef Sienkiewicz.

Intensive work is currently underway to install a small 5-qubit quantum computer at the university within two years. The university is collaborating with various entities, including the Ministry of Digital Affairs.

"We aim to develop an offset that will allow us to control entangled states through appropriately selected electromagnetic pulses. We have signed a cooperation agreement with the Finnish company IQM, which produces superconducting quantum computers. We also hope to expand this small computer to a 150-qubit system in the future. However, even a 5-qubit quantum computer will allow us to conduct numerous research projects and offer exciting educational opportunities for students," concludes Prof. Józef Sienkiewicz.

■ Piotr Kallalas



SLAVES OF ALGORITHMS: ETHICS IN THE AGE OF AI

Interview conducted by Katarzyna Michałowska

Photo Krzysztof Krzempek

In the conversation with **Prof. Włodzisław Duch, PhD, DSc**, we explore ethics in the context of artificial intelligence. The interview gravitates toward admiration for the human brain and its future in the age of technology. The issue of threats associated with addiction to technology and algorithms resonates throughout the conversation.

Prof. Włodzisław Duch demonstrates how technology affects our ability to enjoy the world and emphasizes the importance of interdisciplinarity in the development of AI. He also discusses the evolution of AI systems and their potential applications in process management and optimization.

Towards the end of the interview, Prof. Duch reveals the questions he would ask artificial intelligence and highlights the immense need for seeking good questions and building bridges between different perspectives.

KATARZYNA MICHAŁOWSKA: In recent years, significant progress has been made in AI capabilities, particularly with the latest advancements in language models and mathematical problem-solving. The development of AI is so rapid that every day brings a new innovation or device that incorporates artificial intelligence. Doesn't this seem frightening?

WŁODZISŁAW DUCH: Artificial intelligence is advancing at an incredible pace. You may remember last year when it was claimed that all data had been exhausted, yet after the summer, we witnessed an extraordinary leap in the ability to solve mathematical problems and theoretical issues.

Classes at the Faculty of Architecture / Photo Krzysztof Mystkowski

Cisco published a report stating that the current trend is the decentralization of large models. This presents a significant opportunity to break the monopoly of large companies. It is evident that AI development is beginning to democratize.

Of course, OpenAI is trying to raise expectations, claiming that GPT-5 is coming, and everyone is waiting for it. But at the same time, we ask ourselves what we can expect from GPT-5. Is it about the model's associative capabilities, meaning it will help us write, maybe a little better, or perhaps not at all?

The larger the model, the greater the potential for fabrication and poor associations. The more precise and smaller it is, the greater the chance it will not produce absurdities.

What terrifies me is the human expectation that systems will be omnipotent. People expect them to be almost like Zeus, able to stop earthquakes. Yes, a system could be useful in predicting disasters if it gathers enough data, but it will not stop an earthquake with an invisible hand.

What frightens me is the human approach because it is clear that people want to absolve themselves from thinking and making certain decisions they still must make.

Or perhaps people are simply afraid of this mysterious AI?

Exactly. People fear artificial intelligence. But it is not a devil that will jump out of a box. It is a matter of how we use it.

The fact is that on a societal scale, many people can be dumbed down. People do not verify information, even though there are tools to help fact-check. There is a fear that dark political forces are behind AI. Well, we know this and have plenty of ways to evaluate such systems, to check whether they are truly propagating something or perhaps just making mistakes. After all, every neural network has similar properties.

Humans also make mistakes, don't they?

Yes! I often make comparisons about how our brains work, and it is clear that artificial intelligence is a neural network, something that associates and does not always remember correctly. The human brain also compresses information. For example, when creating large language models, we take 10,000 gigabytes of texts or images and produce perhaps 150 times fewer parameters.

“
The Americans have developed regulations stating that things created solely by artificial intelligence cannot by copyrighted. And that is true, but they added that if a human has made a significant contribution, copyright can be granted.

If someone asks me about the things that every high school graduate should know, I have probably already forgotten them. So, I need to refer to the sources, check them, and only then can I provide an accurate answer. In fact, whenever I write anything, I constantly verify, check, and search to see if I truly remember things correctly or whether I have been mistaken. Because there is a high chance that our neural networks might confuse something.

Large language models or multimodal models do the same. However, many people still imagine that these systems simply quote things as if they remembered and combined them. But that is not how it works!

They function like a normal neural network, reactively. If we are talking now, and you ask me something, things may come to my mind that I may never have thought of before. It is an open system that responds to the external world.

We call it a data flow system, but it does not work like a program because you cannot program it.

Yes, people have tried to create systems based on human, verbalized knowledge. They tried to describe it in detail, but it was not possible to capture all the nuances of language and concept understanding with the use of programming. You cannot create anything like generative artificial intelligence that can produce, for example, fantastic images with programming.

Speaking of images, do we face any legal conflicts related to using artificial intelligence? Where is copyright — on the side of the AI creator or the user?

This is a Pandora's box and one of the topics that limits the development of artificial intelligence: various legal regulations. The Americans have developed regulations stating that things created solely by artificial intelligence cannot be copyrighted. And that is true, but they added that if a human has made a significant contribution, copyrigh can be granted.

What does 'significant contribution' mean? Does it mean one must paint by hand? Not necessarily! Every image created with AI, for example, for sale in someone’s gallery, requires a lot of work.

As we were taught in economics courses, the value of something is frozen labor. It's about how much work one has to put in for the system to produce something that aligns with the artist's vision.

For example, Jackson Pollock rode a bicycle and sprayed paint around. Does that mean the bicycle is the tool that does it? No, the artist had a vision. People using various tools are trying to do something intentionally. If intentions are the determining factor in the creation, then it can be considered value and effort from the artist. Therefore, I believe this is artistic creation.

The act of creating an artistic work and human creativity is astonishing. Do you admire the human brain?

The human brain is the most complex structure we know in the universe.

Our perceptual abilities are astonishing. For instance, a violinist must press the strings exactly where needed because even a millimeter of finger movement changes the tuning of the sound. The sensitivity of our senses is incredible. Evolution has perfected our system of processing information from the senses.

Our brains are the most fascinating objects we know, and perhaps they are unique in the universe we observe.

And today, we are witnessing the next evolutionary step, in which we are building superbrains, which may eventually cause the human brain to fade. Could this happen, Professor?

I hope it does not fade away. However, to a significant extent, if we look at social changes, it may experience some degradation or atrophy, as it is called. This is because we are increasingly relying

> We do not regulate algorithms and we do not regulate mathematics, because it is impossible and it does not make sense.

on technology, which means that people no longer know how to read maps but simply listen to their phones.

Soon, all advisory systems will begin to control us, and we will become, as has already been written in several books on this subject, slaves to algorithms.

It is not good that a significant portion of humanity has lost the ability to live intentionally or to control their own lives.

This is a major danger that technology brings. On the one hand, we can imagine technology helping us achieve wisdom. For example, it can help us understand that short-term goals are less important than long-term ones. We need to think about who we want to become in the future, what we want to achieve, not just that we will have some pleasure from the company of others, stimulants, or computer games.

It would be good if these systems could advise us wisely. But the question remains who can create such systems. It seems that Big Tech is not interested in this, as we know they want to bind us to their platforms to make us watch these foolish things. We stop controlling ourselves and our needs, and let ourselves get pulled in.

Right now, instead of learning to enjoy the world, people just enter social networks and do not see the world beyond them. They do not see it because their noses are in their phones, and they no longer enjoy life. They only enjoy superficial interactions.

This is unfortunately something that technology brings and that has a profound impact on. We see how our students are increasingly unable to focus on anything. Of course, there are a few passionate individuals, and it is great when they are involved in a larger project and put in a lot of effort.

Professor, looking from the perspective of the Gdańsk University of Technology, we have many top-tier specialists here who have trained artificial intelligence. Should the work on the development of AI be carried out in interdisciplinary teams, involving engineers, ethicists, and perhaps even philosophers?

I believe this is absolutely necessary, as there are currently a few really strong groups in this field. DeepSeek has demonstrated that it is possible to achieve better results with significantly weaker systems, without having access to unlimited computational resources. However, the part related to technological development is being carried out only by a small group of people worldwide.

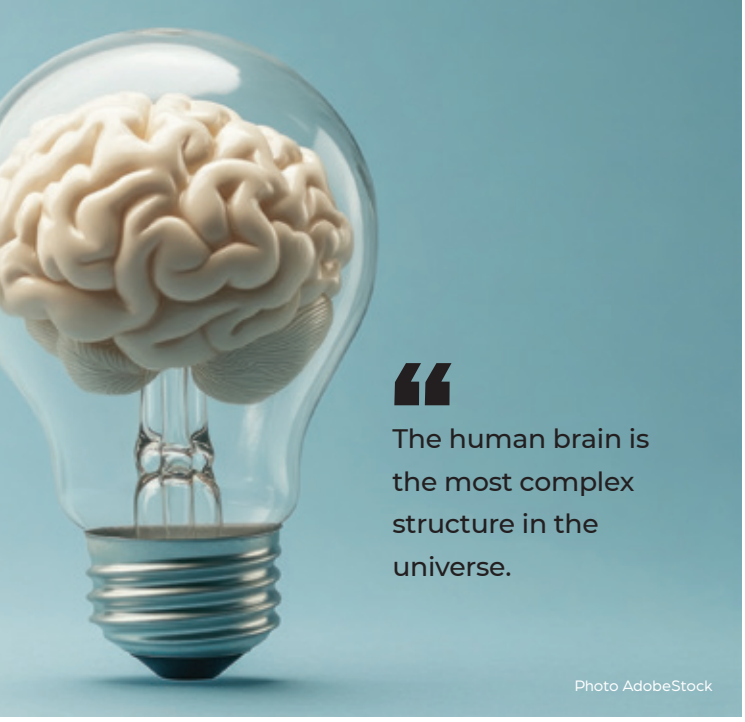
On the other hand, the potential applications of AI systems for specific conditions are broad and will not be dominated by the large companies that have made significant progress in creating large systems up to this point.

Moreover, it seems to me that the initial inspirations for the development of artificial intelligence were somewhat naive. They were based on the assumption that we have knowledge, and we will extract this knowledge from experts and record it in the form of rules. We will create expert systems that will advise us in many fields. There is quite a large branch of applications for such systems, mainly in America.

However, it turned out that many things cannot be done this way, particularly tasks like image analysis, signal analysis, or dialogue systems. It turned out that by creating increasingly larger neural networks, we reached the point where truly complex networks with the appropriate algorithms were able to perform such tasks.

At this point, the networks were primarily inspired by a simple idea: we have many elements working together, like neurons or groups of neurons in the brain. Associative memory arises because the systems learn patterns, and these patterns are asso-

Photo AdobeStock



ciated with each other. Now, if we have a sufficiently large network and we internalize a sufficient number of things in this network, which means, for example, recording all the knowledge of humanity that can be extracted from images and texts, we then have the opportunity to associate observations that are distant from each other because they were made in different fields of knowledge.

A human might not make some associations because there are millions of books to read. To notice something truly groundbreaking, one needs to specialize in a particular field, and then, typically, we fall into certain thought patterns. AI systems, however, have far greater potential to associate different things, from remote fields of knowledge.

As a result, we are starting to look at things that allow us to combine interdisciplinary fields and areas. Recently, it was thought that these were just associative systems like ChatGPT, which emerged two years ago. But suddenly, we are taking the next step, which happened in the middle of last year. We are now able to use older techniques that allow us to explore many more possibilities than just simple associations.

We are transitioning to graphs, meaning more complex reasoning pathways. These are already cognitive inspirations, at the level of thinking or cognition. They require looking at, for instance, psychology, to understand how people reason. From the perspective of creating such systems, is it possible now to move beyond simple biological inspirations?

The future lies in implementing these types of solutions to help us optimize processes at various levels, such as urban governance or intelligent management systems in different companies. To do this, we need to gather data to make our companies operate more agilely. We could create a digital model of the company (a digital twin) or certain areas within the company. Then, we could, at least partially, replace many processes in the company with agents based on artificial intelligence.

This becomes a very interdisciplinary project. Every company has its own specifics, and one must be able to communicate with people. In pharmaceutical companies, a specific language is used, while in city management, it is necessary to understand numerous regulations. This requires collaboration—with, for example, lawyers, people who manage large sums of money, public offices, etc. We need to navigate through a multitude of regulations to understand what is permissible and what is not.

Our opportunity lies in trying to change the organizational culture of various companies.

To make this happen, we need to change the law, regulatory systems, and the management systems we have.

Yes, the European Union recently noticed that regulations might be too strict, and is trying to ease them a bit. I believe we should primarily focus on flexibility and the possibility of implementation.

A lot depends on the field or areas in which a company operates. This requires certain interdisciplinary knowledge: perhaps knowledge of economics, chemistry, or engineering and technical issues, so that we can implement it.

If we, as students or teachers, use AI, is it similar to generating drawings in AutoCAD, or is there something more to it? Are we entering a gray area?

A gray area always exists where it is hard to assess how much of the work comes from humans and how much from the machine's own creativity. The problem is that the machine's creativity is starting to surpass our own.

Slowly, it will become increasingly difficult for us to match what such an intelligent system can do. Until now, people used AI to assist their imagination, to not overlook something or to highlight things that should be included in a publication.

Recently, Perplexity's Deep Research has emerged, a search engine designed specifically for scientific discoveries. I saw Deep Research used in writing a scientific paper, and the text it produced was of a really high quality.

This will happen more and more frequently. I do not know what will happen to our publications because of this. It may turn out that we are less and less the creators, and more and more relying on what the machine comes up with, and there is no clear solution to this.

But at the same time, this is the future. Each of us will have a personal assistant with a few billion parameters, who will know everything we need. We will have it in our phones, computers, or tablets.

This seems to be a Copernican revolution. But referring to Copernicus in the context of artificial intelligence, does the Copernican theory, "bad money drives out good money," apply to AI, which was once trained on books written by humans, but now learns from books written by itself?

An interesting idea, yes. People jump on this technology before it matures.

Many companies started using it, some got disappointed, and this is the danger of implementing various models in real applications in specific institutions. People get disappointed because they used the technology that was not ready for that yet, but after a few months, it becomes much better.

Now we see another phenomenon, which shows that if we have a large model that already knows a lot, we can distill knowledge from it that is useful in various specialized fields, and even quite broadly applicable. In DeepSeek or Deep Research, these models are developed and can solve incredibly complex problems.

Our knowledge grows because we now have various new models of complex phenomena. Especially at the level of molecular biology or genetics, which are so complicated that we are unable to fully grasp them with the human mind. Since there are too many interactions, different molecules, and processes, we have to create such models.

But as a result, there is a significant advancement in knowledge. Yes, these systems use what they have produced themselves.

In this situation, verification is important, that is a good system that could tell whether it is better or worse. In the case of games, we do know it: the game is lost or won. In programming: the program works, does what it needs to do, according to the tests – it is good. But in many other cases, we do not have a gold standard. And we know that the gold standard in medicine is not entirely gold, because diagnoses are almost never 100% certain.

The ability of AI to surpass human capabilities through autonomous learning is thus limited. Therefore, only through collaboration can we go much further. So, I imagine that without human involvement, there will always be many poor books.

In all fields, especially in medicine, machines are beginning to outpace us. That is a very good question: how should we approach this? Should we look at how far we can go thanks to having such systems? It will certainly allow rapid development for companies that learn how to use this technology.

An engineer graduating from the Gdańsk University of Technology must model and train artificial intelligence with careful consideration. And this is the university's responsibility to prepare students from an ethical standpoint. How should we approach this task wisely?

It depends on the field of work. For instance, if someone works in molecular biology and is attempting to discover a new enzyme that genuinely fixes a problem, this requires specialized knowledge, right?

I have long argued that regulation here is very simple: we do not regulate algorithms or mathematics, as they cannot be regulated and doing so would be nonsensical. We regulate everything that is released as a product to the market, especially if it has potential effects or impacts on people. This is similar to how we regulate car safety, by way of conducting various tests. Likewise, we must regulate the safety of administrative systems that may harm people. If we ensure key regulations and tests are followed, avoiding a rushed market release due to external pressures, this will be beneficial.

People will quickly become accustomed to the idea that the system is always correct because, in most cases, it is. However, we cannot allow ourselves to blindly accept the decisions made by such systems.

At the same time, many people refuse to accept the possibility that there is no inherent natural law preventing machines from achieving much higher intelligence than ours. There is no natural law that limits the capabilities of machines to achieve superintelligence. Therefore, I am convinced that superintelligence is approaching rapidly, and we must adapt to this reality.

Professor, what questions would you like to ask artificial intelligence? What answers would you hope to receive?

There are numerous important questions I would like to discuss. I am continuously conversing with AI, trying to extract insights. Soon, there will be a conference on autism in Gdańsk at the Institute for Child Development Support. I am on the advisory board, and, of course, we would like to understand if there is a newer and better therapeutic approach. There is a book containing twenty different theories of autism, and mine is the twenty-first. I would like to know which of these theories is the most plausible one. Perhaps, to some extent, all of them? I am seeking support and counterarguments to various theories, especially mine.

If someone is genuinely working on an issue and recognizes gaps, and it turns out that semantic networks can be used to identify those gaps in our knowledge, where nodes connect different concepts, these knowledge graphs can be used to find areas where significant questions should be asked to build bridges. This is another area worth developing—creating models for building such bridges.

Together with Julian Szymański, PhD, DSc, Eng., my former doctoral student who is now a professor at the Gdańsk University of Technology, we are working on a system that creates a conceptual network showing differences in people's viewpoints. For example, how liberals and conservatives differ in terms of their value systems. This can be observed in conceptual networks, and from there, one can explore the possibility of building bridges to help people better appreciate each other or learn to view things from another perspective.

I could mention more of the things I have attempted in my life that seemed utterly unrealistic at the time, as I am running out of time to complete certain projects. However, thanks to AI tools, there is a chance to achieve something important because I know what to ask. Indeed, finding the right questions is currently the most important task.

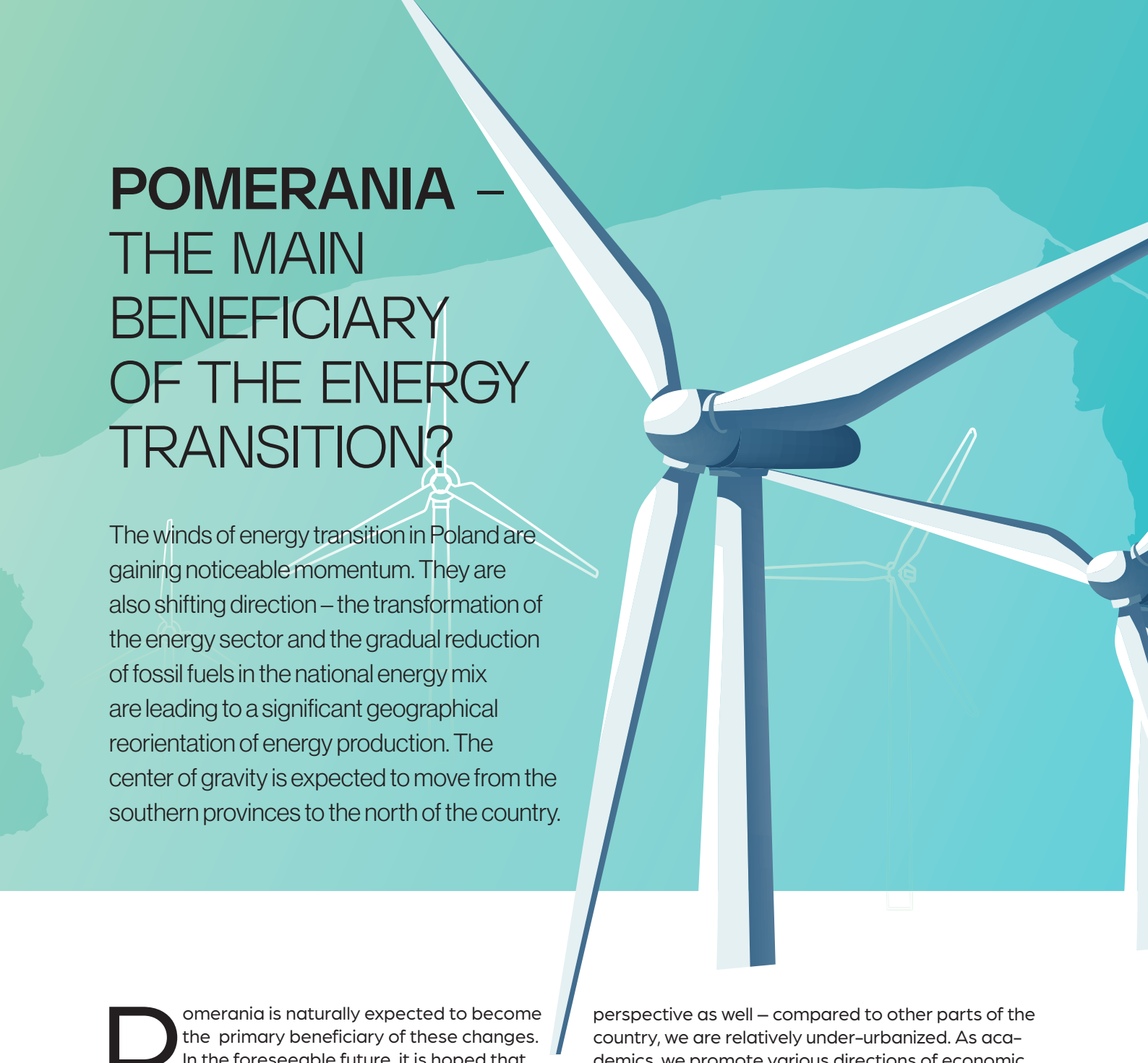
Thus, concluding our conversation, we both encourage asking the right questions. Thank you very much, Professor, for this enlightening discussion.

■ Katarzyna Michałowska

Prof. Włodzisław Duch – Head of the Department of Applied Computer Science at Nicolaus Copernicus University in Toruń. He completed his studies in theoretical physics (1977), defended his doctoral thesis in quantum chemistry (1980), obtained his habilitation in applied mathematics (1987), and next worked at the University of Southern California in Los Angeles (1980–1982). He has worked at institutions such as the Max Planck Institute for Astrophysics in Munich, Kyushu Institute of Technology, Tokyo, Rikkyo, and Meiji Universities in Japan, the University of Florida, and the University of Alberta in Edmonton, Canada. He worked as a Nanyang Visiting Professor at the Nanyang Technological University in Singapore (2010–2012). In 2012–2014, he was the Vice-Rector for Scientific Research and Information Technology at the Nicolaus Copernicus University in Toruń, and, in 2014–2015, he was the Undersecretary of State (Deputy Minister) at the Ministry of Science and Higher Education. He was the President of the European Neural Networks Society (2006, 2008, 2011) and was elected Fellow of the International Neural Networks Society in 2013. He is a co-founder and scientific editor of the journals *Cognitive Science* and *Media in Education*. He is an active member of the IEEE CIS technical committee and an expert in European Union scientific programs. He has published over 450 scientific and popular science articles, authored five books, and co-edited 21 others. His company, DuchSoft, developed the GhostMiner software, which Fujitsu markets.

POMERANIA – THE MAIN BENEFICIARY OF THE ENERGY TRANSITION?

The winds of energy transition in Poland are gaining noticeable momentum. They are also shifting direction – the transformation of the energy sector and the gradual reduction of fossil fuels in the national energy mix are leading to a significant geographical reorientation of energy production. The center of gravity is expected to move from the southern provinces to the north of the country.



Pomerania is naturally expected to become the primary beneficiary of these changes. In the foreseeable future, it is hoped that the region will host both a nuclear power plant and large-scale wind farms. This transformation offers Pomerania the opportunity to evolve from an energy recipient into an energy provider. However, realizing this potential requires forward-thinking strategies, not only in terms of developing new power generation facilities, but also – and perhaps more importantly – in modernizing the energy transmission infrastructure and advancing technologies for energy storage.

"Our energy mix is undergoing a fundamental transformation, but a conscious society must proactively engage with this shift. I speak from a regional perspective as well – compared to other parts of the country, we are relatively under-urbanized. As academics, we promote various directions of economic development. The upcoming investments in Pomerania should be regarded as a proverbial goldmine, and we should make the most of them. It is essential to introduce new technologies to the market, harness the region's existing energy potential, and strategically redirect development efforts toward the north. Gdańsk and the Tricity area are continuously growing and attracting people because progress is being made – but there is always room for more. At present, we enjoy substantial economic development potential. Every transmission of electricity inland results in energy losses, so we should begin developing modern industries locally – for instance, data centers.

> One of the core pillars of Poland's energy transformation strategy is the development of wind power, which has always been envisioned as part of a diversified and environmentally friendly energy mix. We live in a particularly favorable region, rich in wind resources—indeed, one only needs to travel a short distance from the Tricity area to observe the evolving landscape shaped by this shift.

Let me remind you that Google, in response to its immense energy demands for artificial intelligence operations, is buying an entire power plant – specifically, a decommissioned nuclear power plant – for its exclusive use. We will receive this kind of infrastructure as part of our legacy. Low-emission energy will be produced locally. By capitalizing on this, we can elevate our level of development, but this requires a visionary approach," asserts **Prof. Dariusz Mikielewicz**, **PhD, DSc, Eng**., from the Institute of Energy.

The era of energy production heavily reliant on fossil fuels is gradually coming to an end, although this transition continues to provoke debate. Given the knowledge about environmental degradation – irrespective of the energy policies of major greenhouse gas emitters – along with carbon emission charges, aging infrastructure, and the strategic imperative to reduce dependency on foreign energy sources, Poland has joined the global shift toward energy transformation and the search for coal alternatives. Nevertheless, it is important to acknowledge that, in the event of an unexpected reversal of current trends, we have solutions which, if properly refined, could potentially allow for the continued use of coal in an environmentally responsible manner.

"Of course, under current circumstances, a return to a coal-based energy policy appears implausible. However, it must be noted that we possess technologies that allow coal to be used in a clean manner, potentially serving as a solution complementing renewable energy sources. This position may be controversial, but we were once global experts in this domain and held significant expertise. The main obstacle to the development of coal energy has been – and continues to be – the costs associated with carbon dioxide emissions, for which producers face environmental penalties. It is important to recognize that carbon dioxide emissions result from the complete combustion of coal, but there are other pollutants as well, such as carbon monoxide, nitrogen oxides, sulfur oxides, and particulate matter. Both CO_2 and other compound emissions can be captured and repurposed. However, this process adversely affects efficiency. Currently, coal-based power generation operates at an efficiency of approximately 36%, and the implementation of CO_2 capture technologies reduces this figure by roughly 6–8%, resulting in an efficiency of around 28%. Such a scenario is economically unsustainable. Nevertheless, in my view, by improving combustion technologies, we could significantly increase the thermodynamic cycle efficiency. This would enable us, through the additional use of flue gas purification and CO_2 capture and utilization technologies, to achieve – or even surpass – current efficiency levels without generating harmful emissions and, consequently, without incurring the associated penalties," concludes Prof. Dariusz Mikielewicz.

WAITING FOR THE ATOM

Researchers emphasize that despite the rapid development of wind and solar power, a stable energy source, independent of weather conditions, remains essential. In this context, nuclear power emerges as a solution. Unfortunately, the trajectory of nuclear energy development in Poland clearly illustrates that progress in the energy sector is influenced not only

by technological innovation or economic considerations, but is also closely intertwined with the central government policy and regional geopolitics. Poland has been anticipating the commissioning of its first nuclear power plant for over half a century, and despite the existence of a detailed plan, nuclear energy still does not contribute to the national grid.

Globally, the nuclear sector accounts for approximately 10% of electricity production. Under Poland's Nuclear Energy Program, two facilities are planned, with one to be constructed in Pomerania. However, the timeline for the first plant's completion has been repeatedly postponed, with the current projection placing its inauguration between 2035 and 2040.

"A nuclear power plant with a capacity of 3,750 MW is planned for construction in Pomerania. The Polish nuclear energy program faces several key challenges, including securing funds, negotiating market mechanisms with the European Commission, and addressing the availability of qualified workforce. Additionally, the handling of spent nuclear fuel presents a significant issue. Each country adopts its own approach to this challenge – some, such as France, the United Kingdom, Japan, and Russia, employ recycling, representing a closed fuel cycle, in contrast to the open cycle model, which focuses on long-term storage. Alternative methods also exist. For instance, Belgium is exploring transmutation – the bombardment of atomic nuclei with high-energy protons, which may reduce the lifespan of radioactive isotopes resulting from spent nuclear fuel. At present, Poland is adopting an open-cycle approach, which involves storing fuel in long-term repositories. This remains a challenge for the future, as for several decades we will be able to store waste on-site at power plants or in temporary storage facilities. In terms of both volume and mass, the quantities are relatively small, especially when compared to other types of power plants," explains **Marcin Jaskólski, PhD, DSc, Eng., Professor at Gdańsk Tech** from the Department of Electrical Power Engineering.

It is important to highlight once again: Poland requires a stable, 24/7 energy source that is not subject to fluctuating weather conditions. In considering nuclear energy, we must not overlook the concept of SMRs – Small Modular Reactors, with a capacity not exceeding 300 megawatts. A few years ago, plans for such installations emerged in Poland; although enthusiasm appears to have diminished, these smaller-scale facilities offer a range of advantages.

"Small modular reactors could provide entire cities with electricity. Moreover, every nuclear power plant is, in essence, also a facility capable of producing thermal energy. Large-scale nuclear plants are typically located far from densely populated areas, making heat transmission a logistical challenge. In contrast, SMRs may prove an ideal alternative in this regard. Smaller facilities mean reduced emergency planning zones and closer proximity to towns and cities. This option deserves consideration, particularly as our heating infrastructure is also in need of transformation. At present, district heating systems are powered by gas-fired combined heat and power (CHP) plants – in the future, we may shift

> Researchers emphasize that despite the rapid development of wind and solar power, a stable energy source, independent of weather conditions, remains essential. In this context, nuclear power emerges as a solution.

toward hydrogen or other synthetic fuels, but SMRs could serve this purpose as well," notes Prof. Marcin Jaskólski.

Undeniably, one of the foundational pillars of renewable energy development is the solar power sector. Its dynamic growth has been especially observed over the past quarter-century, as engineering solutions have become widely adopted for both industrial and individual use. Photovoltaic panels have reshaped the landscape of both urban and rural areas. Present-day clean energy solutions rely on crystalline silicon, with modules composed of mono- or polycrystalline cells.

"Both monocrystalline and polycrystalline technologies have their respective advantages and disadvantages. However, monocrystalline modules dominate the market due to their higher efficiency. They account for approximately 80–90% of the commercial sector, meaning that nearly all installations observed on rooftops and open land fall within this category. In recent years, research efforts have increasingly focused on third-generation modules, but no major breakthroughs have yet been achieved in this area. Crystalline silicon remains highly advantageous due to its durability and stable performance parameters. If a module is properly manufactured by a reputable company, it can remain operational for 25 years or more. For example, the modules we have had in our laboratory for many years have demonstrated virtually no loss of efficiency. However, it should be noted that these operate under controlled indoor conditions and are not exposed to variable weather factors. At this point, I would strongly discourage the use of low-quality modules originating from the Chinese market – these degrade rapidly, and we often observe clear quality issues as at early as the installation stage," warns **Prof. Ewa Klugmann-Radziemska, PhD, DSc**, Head of the Department of Energy Conversion and Storage.

Researchers note that, at present, there are no revolutionary advancements on the horizon that would significantly increase the efficiency of commercial photovoltaic modules, which currently oscillate at around 23%.

"The annual total solar radiation available under Polish geographic conditions amounts to approximately 1,000 kilowatt-hours per square meter. In ideal conditions, this would allow for the production of 23% of energy – about 230 kWh per square meter of the installation. However, under real-world conditions, where solar irradiation is often far from standard test conditions (STC), the actual output is significantly lower. A promising technology is that of multi-junction or heterojunction cells, which consist of two or three layers that absorb different parts of the solar spectrum. This approach can significantly improve energy conversion efficiency. Such systems can reach efficiencies of up to 40%, which is highly impressive – yet they are very costly at the same time. For commercial users, they remain economically unviable. However, these technologies do find application in sectors such as aerospace," adds Prof Klugmann-Radziemska.

Improving efficiency is just one aspect; solar energy – like wind – is inherently variable, both on a daily and seasonal basis. This underscores the urgent need for investment in energy storage systems that are safe for consumers and can be located close to residential areas.

"Scientists are working on a variety of new technological solutions for energy storage. One such option involves supercapacitors, which are characterized by extremely short charging and discharging times compared to conventional storage devices. They can also undergo a large number of charge--discharge cycles. Nevertheless, any innovation must be evaluated from the perspective of the end user – the solution must be cost-effective, compact, and durable. The disposal of spent batteries is a burden to the environment and is expensive, so we must ensure that energy storage units purchased

today will last for many years. Ideally, we would like recycling processes to enable the recovery of up to 90% of materials for reuse," Prof. Klugmann-Radziemska concludes.

WHAT IS THE FUTURE OF HYDROGEN?

When addressing the issue of energy storage, it is impossible not to mention another promising technology: hydrogen. For several years now, the slogan 'hydrogen is the future' has gained on popularity, and the so-called hydrogen revolution—although still a costly solution—has been regarded as one of the most progressive and potentially transformative concepts in the energy sector. While optimism around hydrogen has not disappeared, it is crucial to understand the current stage of this ongoing process.

"Scientific analyses suggest that hydrogen technology will become widespread around the year 2100. As we are now in 2025, we can already see a defined, although distant, perspective," states **Jacek Gębicki, PhD, DSc, Eng., Professor at Gdańsk Tech** and Director of the Hydrogen Technologies Center. "It is important to recognize that when it comes to decarbonization, there are essentially two pathways: one involves carbon capture and utilization, thereby reducing net emissions to zero; the other relies on the adoption of hydrogenization. The key question, however, is how major global players such as China, India, and the United States—currently the largest emitters of CO_2, unlike Europe—will respond. This raises the issue of whether all stakeholders are working toward a common goal. Poland, for instance, is responsible for approximately 97% of coal extraction in Europe, whereas China extracts, in just two days, the equivalent of Poland's annual coal production. The answer to this question is therefore of fundamental importance."

Assuming, however, that global efforts become aligned, new opportunities may emerge, as hydrogen technology offers significant advantages, including an energy density per unit mass approximately three times greater than that of conventional fuels, and the benefit of zero emissions, as water vapor is the only byproduct.

"The challenge lies in the fact that once hydrogen is liquefied or compressed, the energy yield from 1 kg of hydrogen is reduced, due to the energy consumed during these processes. The hydrogen economy comprises three main stages: production—

Fot. AdobeStock

due to hydrogen's high reactivity, it does not exist naturally in pure form and must therefore be synthesized; storage—since hydrogen is a light element, specialized sealing of pipelines and storage tanks is constantly required, as metallic tanks are prone to hydrogen-induced corrosion; and utilization—if hydrogen is to be used for electricity generation, fuel cells must be employed, which currently operate at an efficiency of approximately 60%," explains Prof. Jacek Gębicki.

Hydrogen is therefore considered as a viable tool for energy storage—an area in which Poland must invest, particularly in light of the fluctuating nature of renewable energy sources.

"With surplus energy derived from solar and wind power, hydrogen can be produced through the electrolysis of water. This hydrogen can then be stored and later converted back into electricity when demand arises. Moreover, this stored hydrogen can also serve as a feedstock for the production of alternative fuels, especially when combined with waste carbon dioxide generated from other industrial processes. Such processes allow for the synthesis of alternative or synthetic fuels, such as methanol or dimethyl ether. Maritime shipping has already shown interest in these solutions, as ship engines powered by methanol are currently being developed," notes Prof. Jacek Gębicki.

WIND GIANTS IN THE BALTIC SEA

One of the core pillars of Poland's energy transformation strategy is the development of wind power, which has always been envisioned as part of a diversified and environmentally friendly energy mix. We live in a particularly favorable region, rich in wind resources—indeed, one only needs to travel a short distance from the Tricity area to observe the evolving landscape shaped by this shift.

"Poland is currently undergoing a dynamic energy transition, significantly reducing its dependence on fossil fuels and diversifying its energy sources. This, in turn, contributes to the enhancement of national energy security. It is worth highlighting that in 2024, the share of renewable energy sources (RES) in the national energy mix reached a record-breaking level of 30%, while coal's share dropped to 57%. The composition of the energy mix is thus undergoing a significant change, and government forecasts project that the share of RES will exceed 55% by 2030. Achieving this target will require investments of approximately PLN 800 billion, along with coherent and stable policies that support the development of green energy. Wind farms and nuclear energy will play a crucial role in realizing these objectives," explains **Michał Wójcik, PhD, DSc, Eng**., Professor at the Gdańsk University of Technology and Director of the Offshore Wind Energy Center.

While financial investment is fundamental, legal and regulatory reforms are also necessary to facilitate and accelerate infrastructure development. This has recently been the case for wind energy, particularly following the amendment of the so-called Wind Turbine Act, which reduced the minimum required distance between turbines and residential buildings from 700 to 500 meters. This regulatory change could, in the short term, increase the availability of land for investment by as much as 50%.

Importantly, wind energy expansion in Poland is not confined to onshore developments. The country is also actively participating in the advancement of offshore wind energy in the Baltic Sea.

"In 2015, installed wind capacity stood at 5 GW. Today, that capacity has nearly doubled. Future plans are ambitious: by 2040, onshore wind capacity is projected to reach 20 GW. Even greater potential is identified in the offshore sector. Poland is planning a major expansion of offshore wind energy in the Baltic Sea, with the first wind farm expected to begin producing electricity in 2026. In the first phase, capacity is projected to reach 6 GW by 2030, with an additional 11 GW expected by 2040. The Baltic Sea has already been included in Poland's maritime spatial development plan. Currently, 19 offshore wind farm projects are underway in Polish waters, all of which have received location permits. Among the key initiatives are: Baltic Power—a project led by Orlen in partnership with the Canadian company Northland Power, involving the construction of 78 turbines, each with a capacity of 15 MW; Baltica 2 and 3—a joint venture between PGE and the Danish company Ørsted, which will install 107 turbines with a capacity of 14 MW each; and the third project developed by Polenergia in cooperation with the Norwegian energy company Equinor," highlights Prof. Michał Wójcik.

Among the key advantages of offshore wind turbines, researchers frequently emphasize the more stable weather conditions and stronger wind currents at sea, as well as the absence of spatial restrictions typically encountered in onshore installations. However, the offshore wind sector also faces several critical engineering challenges.

"Wind variability leads to periodic surpluses or shortages of energy, which necessitates the deve-

A wind turbine blade test stand / Photo Krzysztof Mystkowski

lopment of advanced storage systems. In addition to lithium-ion batteries, alternative solutions are being explored, including compressed air storage and hydrogen-based technologies. Wind farms are often constructed far from major energy consumption centers, requiring the development of new transmission infrastructure. Furthermore, issues such as noise pollution, environmental impact, high investment costs, and complex administrative procedures pose significant barriers. These challenges demand coordinated efforts between government authorities, private industry, and local communities.

As engineers and scientists, we also face a range of technical obstacles. One of them is the need to improve turbine efficiency, currently at a level of 35–50%, which requires the development of new blade designs and the use of advanced materials to effectively capture lower wind speeds. Equally important is the implementation of intelligent wind farm management systems based on artificial intelligence, machine learning, and digital twin technologies. These systems enable real-time monitoring and optimization of turbine operation, resulting in lower operational costs," explains Prof. Michał Wójcik.

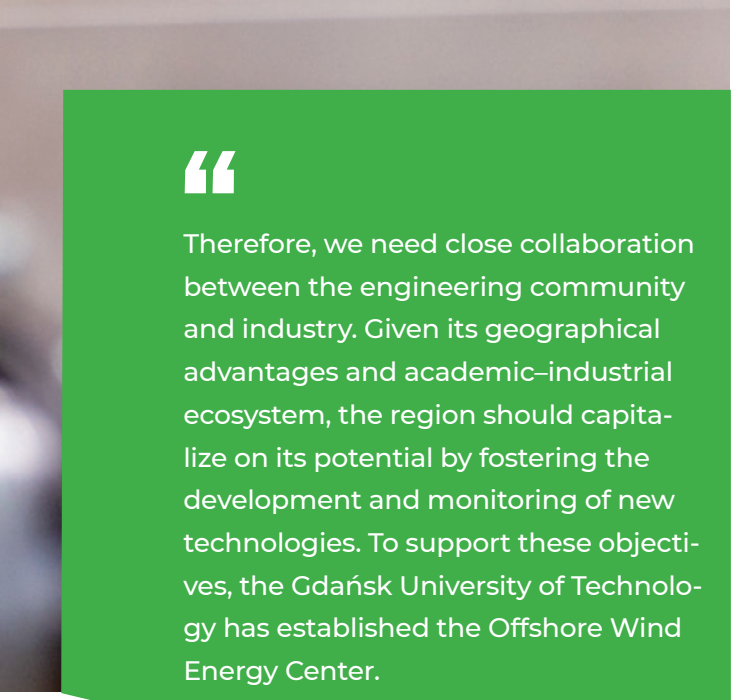
Another ongoing concern is the issue of wind turbine recycling, particularly the recycling of composite blades.

It is worth noting that the marine environment presents far more demanding construction challenges. We are talking about offshore wind turbines that consist of structures with towers reaching diameters of up to 11 meters and heights of up to 250 meters. These towers support nacelles weighing as much as 900 tons, along with rotors whose blades may span up to 120 meters. The entire structure is mounted on a monopile driven into the seabed and must withstand extreme environmental conditions.

Therefore, we need close collaboration between the engineering community and industry. Given its geographical advantages and academic–industrial ecosystem, the region should capitalize on its potential by fostering the development and monitoring of new technologies. To support these objectives, the Gdańsk University of Technology has established the Offshore Wind Energy Center, which is dedicated to advancing knowledge and technology through active participation in various projects.

"Two particularly noteworthy initiatives are DigiWind and HybridWind. The DigiWind project, conducted through international collaboration, aims to train hundreds of students and professionals in cutting-edge digital technologies—essential for the green transition. Beginning in October 2025, a new second-cycle degree program—Smart Renewable Energy Engineering—will be launched at the Faculty of Mechanical Engineering and Ship Technology as part of this initiative. The program integrates advanced digital technologies with wind energy engineering, preparing graduates for employment in the rapidly evolving offshore energy sector.

In turn, the HybridWind project is focused on developing an advanced monitoring and diagnostics system for wind turbines operating under fluctuating temperature conditions, utilizing digital twin technology. Through the application of modern numerical modeling, artificial intelligence algorithms, and machine learning, the system will enable predictive maintenance, thereby reducing operational costs



> Therefore, we need close collaboration between the engineering community and industry. Given its geographical advantages and academic–industrial ecosystem, the region should capitalize on its potential by fostering the development and monitoring of new technologies. To support these objectives, the Gdańsk University of Technology has established the Offshore Wind Energy Center.

and extending the service life of the installations," concludes Prof. Michał Wójcik.

SEIZING THE OPPORTUNITY

Experts are largely in agreement that we are currently on the brink of key energy investments that have the potential to secure Poland's energy system and reduce dependence on foreign sources. The Pomeranian region is expected to play a pivotal role in this transformative process.

"Current national energy development plans include the implementation of three gigawatts of electricity generation capacity from nuclear power and approximately 13 gigawatts from offshore wind installations. All of this energy will supply the Pomeranian region. As a region, we require roughly one gigawatt of power to meet our own needs, which means we will generate a surplus and thus enjoy a significant degree of energy autonomy. Ideally, we will consume a large portion of this energy locally, yet a substantial excess will remain for transmission to other regions. This represents a tremendous opportunity, though it is important to note that we are speaking of long-term implementation—over five years in the case of wind energy and more than ten years for nuclear power. At present, Poland imports a significant share of its electricity—only around 60% is generated domestically," explains Prof. Dariusz Mikielewicz.

This reality must be fully understood not only by national policymakers but also by regional authorities. Regardless of how the geopolitical situation in Central and Eastern Europe evolves, or whether the threat of an armed conflict can be mitigated, the coastal location of the Pomeranian region places it in a privileged position—one that nonetheless demands strategic decision-making in the areas of scientific research, industry, and business, as well as necessary infrastructural transformations.

"A nuclear power plant, as well as both offshore and onshore wind farms, are planned for construction in the Pomeranian region. Projections suggest that our area will generate approximately one-third of Poland's total electricity output. In doing so, we will effectively exchange roles with the Silesian region, emerging as the country's new energy hub," adds Prof. Jacek Gębicki.

■ Piotr Kallalas

Prof. Dariusz Mikielewicz, PhD, DSc, Eng.
Vice-Rector for Research, Institute of Energy, Faculty of Mechanical Engineering and Ship Technology

Marcin Jaskólski, PhD, DSc, Eng., Professor at Gdańsk Tech
Rector's Representative for Nuclear Power, Faculty of Electrical and Control Engineering

Prof. Ewa Klugmann-Radziemska, PhD, DSc
Department of Energy Conversion and Storage, Faculty of Chemistry

Jacek Gębicki, PhD, DSc, Eng., Professor at Gdańsk Tech
Director of the Hydrogen Technologies Center

Michał Wójcik, PhD, DSc, Eng., Professor at Gdańsk Tech
Director of the Offshore Wind Energy Center

ENGINEERING IN HEALTHCARE

Composite cements used in implantology, liquid biopsy, modern regenerative dressings, and finally medical documentation systems for registration and supplementing medical documentation — these are just some of the solutions being developed by research teams at the Gdańsk University of Technology, in close collaboration with medical centers. As a result, diagnostic and therapeutic possibilities are evolving in real time, bringing direct benefits to patients.

Photo Edyta Pilat

There is a science fiction film in which inhabitants of a distant future know exactly at what stage of their lives they will fall ill. All they need to do is show up at the hospital on the designated day and time to receive treatment that will prevent the first mutation from occurring. Watching such productions, we are reminded that this still seems far-off, futuristic, and utopian. However, advanced research is already underway with the goal of detecting pathological changes before an actual tumor forms.

Krzysztof Pastuszak, MSc, Eng., from the Department of Algorithms and Systems Modelling at the Faculty of Electronics, Telecommunications and Informatics is working on early oncology diagnostics. However, his focus is not on imaging techniques, but on the analysis of cancer markers in blood. For this purpose, the potential for conducting the so-called liquid biopsies is being explored.

"In classic biopsy, we extract tissue, which is an invasive procedure carrying risks, and it is not always possible, especially when the lesions are in locations

> Biomaterials represent one of the most pronounced areas of collaboration between medical professionals and engineers. An example of such collaboration is bone cements—ceramic and polymeric.

that are not easy to reach. Liquid biopsy involves collecting material—usually blood, but it can also be urine or a swab—in the context of searching for markers signaling the development of a disease," explains Krzysztof Pastuszak, MSc, Eng.

The goal is to detect something that cannot yet be seen, even with MRI or CT scans. Therefore, scientists are not focusing on symptomatic patients, but on those at an extremely early stage of tumorigenesis.

"Promising screening tests are those based on genetic material. One can analyze circulating DNA and RNA profiles from blood platelets, which are associated with clotting processes, but also play a significant role in complex immune reactions and have a strong interaction with tumors. Most studies on liquid biopsies focus on DNA, which platelets lack. In our work, we focused on RNA, which shows the dynamics of various factor productions. Based on RNA profiles, we attempt to decipher whether the patient is sick or not," adds Krzysztof Pastuszak, MSc, Eng.

The ideal solution would be tests capable of detecting multiple types of cancer. Currently, scientists are using machine learning to search for patterns that enhance diagnostic capabilities. Interestingly, this type of solution is no longer just a film director's fantasy. The technology is now infiltrating the medical service sector and is starting to be used in hospitals.

"Traditional biopsy is always more accurate, but it is unsuitable for screening tests. The goal is to reach a large number of individuals. The results of our work are promising. Medicine faces the challenge of creating universal tests for detecting multiple cancer types. The problem is that for different types of cancer, the circulating material appears at different stages—sometimes earlier, sometimes only when the disease is at an advanced stage. However, in the U.S., the first liquid biopsy-based tests have already been approved for sale and use. Of course, they do not detect all diseases, but at least over a dozen," says Krzysztof Pastuszak, MSc, Eng.

IMPROVING DOCTOR-PATIENT COMMUNICATION

New medical technologies do not always need to be associated with groundbreaking oncology therapies or spectacular diagnostics. Sometimes, a modern engineering approach can improve the quality of services and communication between doctors and patients. An example of this approach is the Admedvoice project, which has been in development since 2023 and reflects the ongoing attention of researchers to the current needs of medical professionals.

"The goal is to develop a system for recording the course of doctors' work with patients in clinical situations. This includes enabling the recording of conversations during clinical encounters such as doctor visits, examinations, emergency room admissions, resuscitation efforts, and surgeries, and converting these recordings into structured formats. The conversation between the doctor and the patient or among medical staff is transcribed and then structured into forms containing key patient information, from the doctor's perspective," explains **Franciszek Górski, MSc, Eng.**, from the Faculty of Electronics, Telecommunications and Informatics.

The current healthcare system in Poland faces a shortage of medical staff, while the number of patients continues to rise. Doctors currently lack time for many tasks, and during consultations, they must balance focusing on the patient with ordering necessary procedures and entering all information into the system.

"Our solutions use the latest neural network architectures and inference techniques. For transcription, we use neural automatic speech recognition systems, specifically trained on medical speech corpora in Polish, prepared by our teams. Additionally, we developed a system to correct transcrip-


Photo AdobeStock

GDAŃSK TECH SCIENTISTS IN THE SERVICE OF MEDICINE

Prof. Jacek Rumiński, PhD, DSc, Eng. A scientist, engineer, and educator in the fields of biomedical engineering, computer engineering, and computer science. He is the Head of the Department of Biomedical Engineering at the Faculty of Electronics, Telecommunications and Informatics. He is a member of the Committee of Biocybernetics and Biomedical Engineering of the Polish Academy of Sciences, the Chair of the Scientific Council of the Polish Artificial Intelligence Society, and a member of the Human Factor Committee of the IEEE Industrial Electronics Society. His research focuses primarily on medical imaging, image processing, machine learning and data mining methods, human–system interaction, and technologies supporting quality of life. He has worked as a coordinator or principal investigator in approximately 20 projects that have received numerous awards, including for the best papers at conferences and for innovation (more than 25 awards and medals in total), as well as the Andronicos G. Kantsios Award. Prof. Rumiński is the author of over 200 scientific publications and several patent applications and granted patents. Most of his research involves the use of machine learning methods and the development of new algorithms in this field. He is also the co-founder and president of the Artificial Intelligence Bay (AI Bay) Club.

Michał Kucewicz, PhD, DSc, Professor at Gdańsk Tech He specializes in the electrophysiology of memory and cognitive brain functions. At the Department of Multimedia Systems, the Faculty of Electronics, Telecommunications and Informatics at the Gdańsk University of Technology, he established the Brain and Mind Electrophysiology Lab. He also collaborates with the Mayo Clinic in the United States, where he conducts research on memory, working with patients with epilepsy. He carries out multidisciplinary projects aimed at advancing brain electrical stimulation technologies to enhance memory in patients suffering from epilepsy, Parkinson's disease, and other neurodegenerative disorders. Since 2021, he has participated in pioneering brain surgeries in Poland, during which he records signals associated with memory encoding and retrieval using specialized electrodes implanted deep into the patient's brain. The goal of his research is to discover the bioelectrical activity of the brain underlying human concepts, thoughts, and consciousness.

tion errors through a separate language model. For structuring the transcription, we use large language models, which demonstrate high accuracy in classifying medical texts in Polish without the need for further training. In this way, we have developed a system that allows for highly accurate transcription and structuring of medical texts from recordings of various clinical situations," says Franciszek Górski, MSc, Eng.

Researchers have now completed the second phase of the project, while the stage of preclinical studies is still ahead of them. If successful, a pilot implementation will begin within two years at the University Clinical Centre.

MATHEMATICS IN DIAGNOSTICS

The creation of biomaterials, the search for new biotechnological solutions, and even bioinformatics are clear examples of the integration of engineering and medicine. However, pure mathematics is also proving valuable in medical technologies.

"We are developing new mathematical methods based on chaos theory and topology, which are successfully applied, for example, in heart disease diagnostics. Our team works closely with the Gdańsk Medical University and the University of Gdańsk within the Fahrenheit Universities Consortium," says **Prof. Grzegorz Graff, PhD, DSc,** from the Institute of Applied Mathematics at the Faculty of Applied Physics and Mathematics. "Medical diagnostics requires an interdisciplinary approach

> We are developing new mathematical methods based on chaos theory and topology, which are successfully applied, for example, in heart disease diagnostics.

and close collaboration between doctors, engineers, physicists, and mathematicians. In our case, the starting point is the heart rhythm analysis, but our research also includes blood pressure and respiration. Even ECG data alone provides valuable information about the body's condition, and additional information about blood pressure and respiration allows for more precise health status determination."

Prof. Graff points out that one of the key challenges in analyses is interpreting respiratory recordings. Understanding patterns in breath structure could open new diagnostic possibilities. In this regard, researchers are collaborating with the Max Planck Institute to create a classification system for breathing patterns. Let's get back to the tools, however – how can topology be used in diagnostics?

"A rapidly developing branch of topology, known as topological data analysis (TDA), provides universal methods applicable across various fields—from medicine to economics. TDA deals with the shape of data and allows us to uncover unique patterns that may be overlooked with traditional signal analysis techniques. Moreover, this method is resistant to noise and disturbances. By analyzing data in a multidimensional space, we can identify relationships and dependencies that would not be visible in classical one- or two-dimensional analysis. We have successfully used TDA to study ECG data and are currently expanding its application to blood pressure and respiratory parameters," explains Prof. Graff.

In their work, the research team is also focusing on sleep apnea, a common phenomenon associated with an increased risk of cardiovascular incidents.

"Analyzing ECG and blood pressure signals during the day can provide information that allows us to predict the risk of night-time apnea. As we have demonstrated, the breathing rhythm of patients with nocturnal apneas is also altered during the day. We are currently working on patenting an innovative diagnostic method for this condition based on this observation," adds Prof. Graff.

BIOCOMPOSITES WITH OPTIMAL PROPERTIES

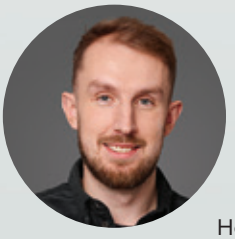
The development of engineering solutions with medical applications is possible only through close collaboration between both worlds. Researchers develop solutions, but it is the medical personnel who signal what is truly needed—both in terms of improving diagnostics, therapeutic solutions, and streamlining doctors' work.

"Interdisciplinarity is crucial in my scientific work. Biomaterial engineering itself integrates physics, chemistry, and biology, enabling the development of new materials for medical applications. At every opportunity we try to engage with our partners from the medical world to understand the problem at hand and the potential for improvement. Although we develop innovative technologies, their implementation requires adaptation to the practical needs of surgeons and end users. Therefore, understanding their expectations is essential to ensuring that the final solution is functional," says **Marcin Wekwejt, PhD, Eng.**, from the Department of Biomaterials Technology at the Faculty of Mechanical Engineering and Ship Technology (FMEST).

Biomaterials represent one of the most pronounced areas of collaboration between medical professionals and engineers. An example of such collaboration is bone cements—ceramic and polymeric—used in injectable form to bind and stabilize fractures, anchor implants, and ultimately promote tissue regeneration.

"In our research, we are developing new types of cements—so-called composite cements—obtained by combining two main types of biomaterials: polymers and ceramics. The result is a 'biphasic' material, combining the properties of both ceramics and

Prof. Jerzy Wtorek, PhD, DSc, Eng. A researcher at the Department of Biomedical Engineering at the Faculty of Electronics, Telecommunications and Informatics. He conducts research projects focused on improving non-invasive diagnostic methods for the respiratory and cardiovascular systems. In collaboration with teams from the Gdańsk University of Technology (Gdańsk Tech) and the Medical University of Gdańsk (GUMed), he investigates the properties of electrocardiographic (ECG) signals for respiratory monitoring, aiming to develop a measurement protocol that accounts for individual patient variability. His further research involves the processing of ECG and photoplethysmographic signals to develop methods for continuous, non-invasive blood pressure measurement. Among the projects he is currently working on there are: a biopsy instrument designed to preserve sample integrity; a method and device for assessing circulation within the gastrointestinal tract (particularly in the intestines during surgical procedures); and the evaluation of blood circulation in composite skin flaps following the removal of extensive cancerous lesions.



Sebastian Cygert, PhD, Eng. He is an assistant professor at the Department of Multimedia Systems at the Faculty of Electronics, Telecommunications and Informatics. He specializes in the field of artificial intelligence. His research focuses on the development of reliable and adaptive machine learning models. In contrast to static models, which remain unchanged over time, these models are characterized by their capacity for autonomous adaptation and effective operation in dynamic environments. Such algorithms are applied, among other areas, in medicine—for example, in the analysis of medical images—where they must adapt to emerging diseases such as new viruses, as well as to evolving forms of existing conditions. Sebastian Cygert, PhD, is involved in the ADMEDVOICE project led by Prof. Andrzej Czyżewski. He also collaborates with the Medical University of Gdańsk on a project involving early cancer diagnosis using liquid biopsy and deep learning methods. This approach enables early cancer detection, identification of its origin, and it also supports medical decision-making processes. Doctor Cygert's research has been published at leading AI conferences, including NeurIPS, ICLR, and ECCV.

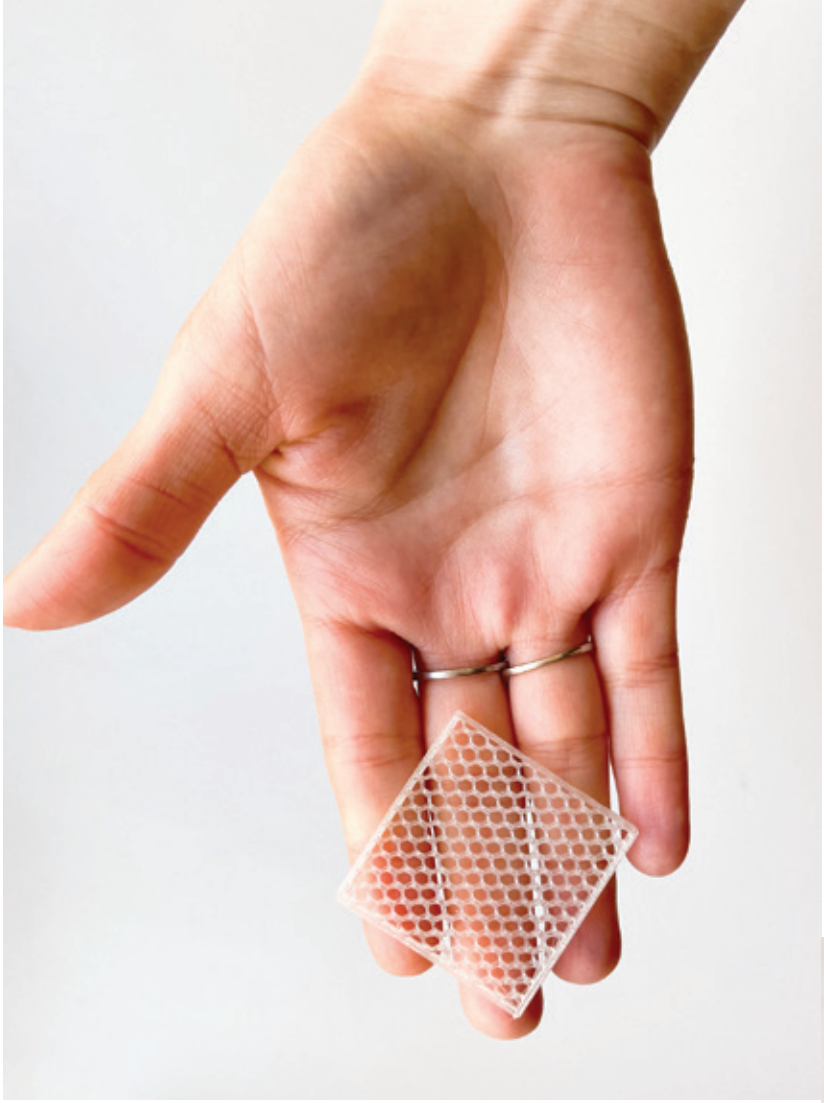
polymers, yielding a synergistic effect. Generally, ceramics exhibit high bioactivity and stimulate tissue regeneration, while polymers have interesting mechanical and plastic properties," explains Marcin Wekwejt, PhD, Eng.

In the case of polymer-based solutions, the challenge lies in modifying synthetic materials to achieve new, beneficial properties for patient recovery, such as partial biodegradability or antibacterial features. Ceramic cements, on the other hand, pose different challenges.

"After my doctoral studies, I began working on ceramic cements, focusing on magnesium phosphate, which supports healing defects and encourages active tissue regeneration, particularly important for osteoporosis. However, ceramic cements, including magnesium phosphate, have limited injectability, poor cohesion in aqueous environments, and significant brittleness. Thus, we decided to modify them by adding a hydrogel component—creating a composite. Our developed cements combine two hardening processes: the hydraulic reaction of ceramics and the crosslinking of hydrogels, which allows for better control of their properties," explains Marcin Wekwejt, PhD, Eng.

The researcher is currently working in Canada as part of the BEKKER (NAWA) program, within the Biomaterials and Bioengineering Team led by Professor Diego Mantovani at Laval University. There, a new implant system known as the tissue anchor is being developed. This system will provide a source of magnesium-based bone cement with the potential for regeneration of spinal column tissues, bones, and teeth.

"The system consists of a metal scaffold filled with a bioactive hydrogel, which supports bone regeneration and implant stabilization. When we have a tissue anchor and attach it to a bone of poor quality, this implant will not be stable, and it is meant to serve as an attachment for soft tissues: tendons, ligaments, or cartilage. Therefore, we are actively working on a new system. Our solution is based on biodegradable metal, and my main task will be to fill it with chitosan bioactive hydrogel, which has antibacterial properties, and further modify it by introducing magnesium, which additionally stimulates bone tissue regeneration. We aim to create a biocomposite as an integral part of the implant, possessing the best possible



can be tailored to the individual needs of the patient. The developed structures consisted of several layers containing, among others, antibiotics, vitamin C, and collagen, aimed at accelerating the regeneration process," says **Justyna Kucińska-Lipka, PhD, DSc, Eng.**, Gdańsk Tech Professor, Vice-Rector for Development.

All of this fits into personalized treatment techniques, where appropriate engineering solutions are 'tailored' to both disease conditions and individual patients.

"Polymers play a crucial role in modern medicine thanks to their unique biological properties. When properly selected, they exhibit high biocompatibility and can be used both as permanent implants, such as pacemaker components, surgical meshes, screws, or plates, as well as in the form of biodegradable

Photo Edyta Pilat

properties for the needs of modern medicine," adds Marcin Wekwejt, PhD, Eng.

UNLIMITED POSSIBILITIES OF POLYMERS

Polymers, due to their properties and characteristics, are also used in numerous areas of medicine as carriers of active substances, dressing elements, and also, as previously mentioned, implants. In combination with active substances, they can aid regenerative processes and provide bacteriostatic protection to secure wounds.

"As part of our cooperation with the Tissue Engineering and Regenerative Medicine Laboratory at the Gdańsk Medical University, we developed innovative multilayer dressings for the treatment of hard-to-heal wounds. These hybrid materials consist of a hydrogel layer containing active substances and a scaffold made of thermoplastic polyurethane, ensuring the dressing's stability. Importantly, thanks to 3D printing technology, each dressing

structures. The latter undergo controlled degradation at a rate adapted to tissue regeneration processes, allowing them to be gradually replaced by newly formed tissue. Thanks to the appropriate design of polymer materials, we can precisely regulate the rate of active






Krzysztof Pastuszak, MSc, Eng.
Department of Algorithms and Systems Modeling, Faculty of Electronics, Telecommunications and Informatics

Franciszek Górski, MSc, Eng.
doctoral student in the Department of Multimedia Systems, Faculty of Electronics, Telecommunications and Informatics

Prof. Grzegorz Graff, PhD, DSc
Department of Differential Equations and Applications of Mathematics, Faculty of Applied Physics and Mathematics

Marcin Wekwejt, PhD, Eng.
Division of Biomaterials Technology, Faculty of Mechanical Engineering and Ship Technology

Justyna Kucińska-Lipka, PhD, DSc, Eng., Professor at Gdańsk Tech
Vice-Rector for Development, Department of Polymer Technology, Faculty of Chemistry

Jakub Baczyński-Keller, MSc, Eng.
doctoral student in the Department of Biotechnology and Microbiology, Faculty of Chemistry

substance release and control the biodegradability of products, which, after fulfilling their function, decompose, eliminating the risk of their retention in the body," adds Prof. Justyna Kucińska-Lipka.

Another area of polymer application is cardiology and cardiac surgery, where polymer coatings are used for stents. After placement in blood vessels, these coatings release therapeutic substances that prevent further cardiovascular incidents.

"In recent years, we have conducted a number of projects aimed at developing innovative biomaterials. One of the key achievements was the creation of components for pumps supporting the left ventricle of the heart for patients with end-stage heart failure. For this purpose, we used modified polyurethanes enriched with active substances that ensure long-term material stability in a biological environment and controlled release of anticoagulant substances," emphasizes Prof. Justyna Kucińska-Lipka.

Interestingly, in this case, the implementation of new solutions, which will benefit patients, does not necessarily require years of clinical trials. Scientists, in addition to creating new materials, also use those already approved for medical use. Modifying such products allows for shortening the certification process and speeding up their direct application in therapeutic processes.

"MEDICINE AND SCIENCE ARE DEVELOPING AT AN UNPRECEDENTED PACE"

Scientists and clinicians place great hopes for regenerative medicine, which supports the processes of rebuilding damaged tissues and organs, aiming to accelerate wound healing and shorten the recovery period after procedures and surgeries. A number of teams are working in this area, including neurologists, geneticists, and engineers in biotechnology or chemistry.

"Regenerative medicine encompasses various strategies: from cell therapies to organ cultivation and epigenetic therapies. By utilizing stem cells, biomaterials, or biologically active substances, we are able to stimulate natural regenerative processes. In addition, technologies are being developed to enable the cultivation of tissues and entire organs under laboratory conditions, as well as the use of genetically modified animal organs. If these methods become widely available, they could significantly reduce the number of patients waiting for transplants by providing new sources of organs," points out **Jakub Baczyński-Keller, MSc, Eng.**, from the Faculty of Chemistry.

Medical progress is also inextricably linked to social concerns, with fears about excessive interference in the human body, gene manipulation, and the use of organs for transplant purposes.

"As scientists, we not only have the duty to search for new solutions but also the responsibility to build social understanding and acceptance of these innovations. It is hard to talk about animal organ transplants when the usefulness of vaccinations is being denied in everyday life. Medicine and science are developing at an unprecedented pace, but without an open and informed dialogue about their possibilities, we risk not fully benefiting from these achievements," concludes Jakub Baczyński-Keller, MSc, Eng.

■ Piotr Kallalas

CONTEMPORARY CITIES – ECONOMICS VS. SUSTAINABLE DEVELOPMENT

Photo Krzysztof Mystkowski

"If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."

(The Limits to Growth, 1972, p. 32)

More than 50 years have passed since the publication of the Club of Rome's report *The Limits to Growth* (1972), which laid the groundwork for the definition of sustainable development. Among its key arguments, the report highlighted the crucial role of cities in avoiding ecological crisis.

This informal international organization—founded in 1968 and comprising scientists, politicians, and business leaders—focuses on global challenges, including environmental threats. The report it released shocked public opinion worldwide.

A REJECTED REPORT

"*The Limits to Growth* laid the foundations for thinking about sustainable development," says **Robert Skrzypczyński, PhD, Eng**. "It is worth noting, however, that its very interesting conclusions met with widespread criticism and, in my view, even denial. The report was not translated into any policy, and within expert circles, it was mostly dismissed as overly pessimistic. What is striking is that the report was practically discredited as catastrophist and overly emotional."

Photo Agata Cymanowska

> Urban planners, architects, analysts, and researchers are leaders in the field and should act as trendsetters in shaping the future of city design and transforming urban infrastructure to support healthy urban ecosystems.

"With regard to the skeptical reception of the document, we see similar reactions today toward reports on climate change and environmental conditions," points out **Katarzyna Zielonko-Jung, PhD, DSc, Eng. of Architecture, Professor at Gdańsk Tech**. "These reports also forecast transformations that will directly affect economic development, demographic trends, and our ways of life. Only after years of escalating climate crisis and irrefutable evidence of its reality do we begin to reflect—yet that is undoubtedly lost time."

"Everyone says something must be done, and, in theory, much is happening around these issues. Policies, documents, and declarations are being created. However, it is extremely difficult to achieve real results, whether in terms of countering climate change or meeting the challenges of sustainable development," assesses Prof. Zielonko-Jung.

THE IDEA OF SUSTAINABLE DEVELOPMENT

The concept of sustainable development emerged roughly a decade after the Club of Rome's report was published.

"*The Limits to Growth* presented scenarios for the future that laid the foundation for thinking about sustainable development," says Robert Skrzypczyński, PhD, Eng. "Of course, parts of the model used in that report can now be updated after fifty years, and that is exactly what is being done. Some of the conclusions today differ, but the report remains a significant step in the debate," the researcher concludes.

The report sold thirty million copies and was translated into more than thirty languages.

"It was indeed the beginning of a broader discussion and laid the groundwork for formulating the idea of sustainable development, which at the time had not yet been explicitly defined," confirms Prof. Zielonko-Jung. "That definition began to evolve somewhat later. In fact, the idea is still being shaped, as it is difficult to pin down—it encompasses a wide range of issues. Certain aspects have gained prominence over time, while others—initially less recognized, underestimated, or entirely new—have become impossible to ignore. Currently, sustainable development is defined through the lens of the seventeen Sustainable Development Goals," she adds.

"Every time I hear the term 'sustainable development,' I get the impression that we are working with a set of expressions that refer to similar trends under different names, each with its own cycle of relevance," says **Aleksander Orłowski, PhD, DSc, Eng.**, Professor at Gdańsk Tech. "Whether we talk about sustainable development in cities, smart cities, or today's climate protection initiatives, they are to a large extent linked to the commercial domain. Unfortunately, I often feel that, in discussing climate change, we are—just as the professor mentioned—resorting to slogans," Prof. Orłowski concludes, offering a different perspective.

SCIENTISTS AS TRENDSETTERS

"Certain trends are already emerging. One of the most visible today is the focus on blue-green urban infrastructure," says Prof. Katarzyna Zielonko-Jung. "Until recently, we spoke mainly about greenery. Now, much greater emphasis is being placed on water and the integration of these elements into a single, coherent, biodiverse, and resilient system. In the context of cities, this is a strong example of how our understanding of sustainable development is evolving."

Cities are increasingly caught between the opposing forces of urban sprawl—the decentralization of population and employment to suburban municipalities—and the compact city model, which promotes dense, thoughtfully planned urban development.

"Theoretically, we know what must be done to improve urban conditions, but, in practice, economic imperatives often overpower all other trends and challenges," observes Prof. Zielonko-Jung. "There is a significant gap between the rhetoric and what actually happens. We know we must protect blue-green infrastructure—both in individual planning decisions and broader urban policies. And indeed, in many cities, for example, rows of trees are planted along the existing streets. Yet, at the same time, decisions are made to intensively develop the last remaining open spaces, often resulting in high-density construction with little to no provision for green areas," she explains, highlighting the conflict of interests.

"I believe we are still struggling with the conceptual foundations, which makes many actions unfeasible because their assumptions are internally inconsistent," says Robert Skrzypczyński, PhD, Eng. "For example, compare the definition of sustainable development from the 1987 Brundtland Report with the version promoted by the Ministry of Development and Technology. The Ministry claims the original definition emphasized balancing the needs of current and future generations, but that over time it has evolved to emphasize balance among economic, social, and environmental aspects."

"In my view, the Ministry's definition contains a kind of loophole that ultimately leads to prioritizing economic interests above everything else," concludes Robert Skrzypczyński, PhD, Eng.

A stereoscopic projection with a mockup of the city of Gdansk in the Immersive 3D Visualization Lab / Photo Krzysztof Mystkowski

> What is most important today is that we attempt to move away from the siloed approaches to management and problem-solving.

DEPARTMENTS AND DIVERGING GOALS

A clear divergence emerges between the environmental aspirations of creating ecologically resilient urban ecosystems and the economic imperative to maximize land development.

"I believe that one of the most pressing challenges for cities today is the need to overcome a siloed approach," says Prof. Aleksander Orłowski. "Urban authorities, in particular, are extremely silo-based. Here are the transport officials; over there are those responsible for education."

"For instance, in one of the cities in southern Poland, a school network was restructured, and the Department of Transport was surprised to find that some bus routes were extremely busy on September 1st," continues Prof. Orłowski. "An external audit revealed that the changes were implemented by another department within the same city office."

"We must approach problems more holistically. And that means integrated data systems," he adds. "This is foundational work—it will not yield spectacular short-term results, but without it, implementing meaningful change is extremely difficult."

"It is not the case that business is only interested in profit and nothing else," says Prof. Orłowski. "Of course, some individuals are purely profit-driven, but even in the development sector, there are those who respond to evolving customer expectations and strive to meet broader needs. The key is to define clear requirements."

"I believe that while businesses may aim to do something good within certain limits, those limits are rigid—ultimately, the goal remains profit," opposes Robert Skrzypczyński, PhD, Eng. "No declaration can change that. I think economic priorities dominate in part because many stakeholders now understand 'development' through the Ministry's newer lens: balancing economic, social, and environmental growth. That redefinition subtly shifts the emphasis."

"Another issue is that cities today are no longer truly planned—they are managed operationally," Prof. Orłowski notes. "If an investment is needed, we simply amend the local spatial development plan


Photo AdobeStock

for that specific case. Yet how many urban developments are actually based on projected population growth over the next 20 years?"he asks rhetorically.

"The estimates vary, but if tens of thousands of new residents are expected, are we planning where they should live? What kind of transport infrastructure will serve them? And are we using these data to inform our spatial planning decisions?" he asks again.

"Of course, that would be an ideal approach, but such planning improves predictability—and predictability helps commercial subjects operate more effectively," he concludes.

"I believe we prioritize economic growth over both social and environmental development. But today, nature must not only be protected—it must also be restored and regenerated," emphasizes Robert Skrzypczyński, PhD, Eng. "This argument is much broader, grounded in data that clearly show environmental degradation correlates with economic growth. While this correlation can be mitigated to some extent, the goals of environmental protection and continued economic expansion remain fundamentally contradictory for now," he concludes.

"I still maintain that business is not the root cause of the problem. No sector is more innovative than the commercial one. The real question is: how can business and the environment interact productively?" responds Prof. Orłowski.

INTERDISCIPLINARITY VS. ORGANIZATIONAL STRUCTURE

Urban planning involves a multitude of interested parties, which indicates that engineers and planners should address problems in an interdisciplinary manner together with local government representatives. Is this easy to accomplish, and how can it be done?

"Together with the city of Gdynia, we are preparing to study the possibilities of shaping the landscape and the organizational actions of local authorities aimed at minimizing human-wild boar conflicts. We are all aware that wild boars are increasingly present in cities," provides an example Robert Skrzypczyński, PhD, Eng. "I tackle this issue while collaborating with biologists, but I constantly get the impression that some people discourage interdisciplinary cooperation. In my field, I sometimes encounter the rather peculiar opinion that the issue of wild boars in cities has nothing to do with spatial planning. We often speak about interdisciplinarity and the need to avoid isolation within our disciplines, yet putting this into practice is often arduous. Nevertheless, the attitude of the Gdynia authorities deserves praise—they have established an interdisciplinary team on wild animals that addresses the issue from multiple perspectives," says Robert Skrzypczyński, PhD, Eng.

"I work with various cities, and one of the elements we address is the need to change organizational structures," says Prof. Aleksander Orłowski. "People engaged in planning insist they only deal with that specific task. It is the same at the university. Everyone talks about interdisciplinarity, but in the end, what matters is what we do within our own discipline. This is the case in most professional environments," highlights Prof. Orłowski.

"However, as long as no management decision is made to change the organizational structure to one that breaks down silos and enforces a problem-oriented rather than department-oriented perspective, it is difficult to expect employees to behave differently. Yet problems are not limited to single domains, hence the necessity to reform organizational structures. Cities around the world are facing this

challenge—some are handling it better, while others are not even fully aware that such changes are necessary," concludes Prof. Orłowski.

REDUCING THE STANDARD OF LIVING AND LIMITING CONSTRUCTION

Organizational changes and goal-setting are one thing, but public attitudes toward imposed or enforced changes are another. Much is said about the circular economy or regulations imposed on the construction industry, but do we build thoughtfully, or only to generate profit?

"If everyone in the world were to achieve a standard of living commonly deemed satisfactory—that is, the level of the American middle class—there would not be enough resources or space for humanity. We would need another planet," says Prof. Katarzyna Zielonko-Jung. "As a civilization, we are reluctant to accept the fact that we must lower the living standards of wealthier societies, and give up comfort, or at least reevaluate it. When we speak honestly about sustainable development, we must also speak about justice and equalizing opportunities."

"As a society, we are addicted to the paradigm of constant growth—not necessarily because we want more, but because we feel we need more," adds Robert Skrzypczyński, PhD, Eng. "We are addicted in many ways to this model, even though we see that it produces absurd outcomes."

"It is worth mentioning the circular economy model. While the idea of sustainable development in terms of renewable energy or environmental protection is somewhat understood and implemented to varying degrees, the concepts of circular economy and closed-loop systems remain far from being adopted in the construction sector," states Prof. Zielonko-Jung. "It has long been known that we are polluting the planet, yet we can still buy four apples on a polystyrene tray wrapped in plastic. If we have not been able to regulate such a simple issue as packaging, what can be said about buildings? Without decisive legal prohibitions and mandates regarding more resource-efficient management and reuse, we will achieve no tangible results," she continues. "The business lobby defends the status quo because stricter requirements would force profitable enterprises to undergo radical changes, which is not in the owners' interest."

"We impose high standards on new buildings, for instance in terms of energy efficiency and technical

solutions, yet a greater problem lies in adapting the existing building infrastructure to current conditions. It is very difficult to obtain funding for modernization and reconstruction," says Prof. Zielonko-Jung. "Moreover, we have many buildings that may become obsolete in the future. Shopping malls are a good example, for instance—people might no longer shop in this manner, leaving many unused buildings behind. Increasingly, technically sound buildings are being demolished just to construct new ones on the same plot, simply because the land is so expensive that it becomes profitable. Do we really need this? In reality, it is about generating profit. We claim people have no place to live, yet are the buildings being constructed around us really intended for those in housing need?" she questions.

"Walking past numerous construction sites in Gdańsk, I often come across signs announcing the development of investment apartments. These are not even referred to as multi-family buildings anymore," shares Prof. Zielonko-Jung. "The standard of new construction, particularly in urban terms,

> We impose high standards on new buildings, for instance in terms of energy efficiency and technical solutions, yet a greater problem lies in adapting the existing building infrastructure to current conditions. [...] Moreover, we have many buildings that may become obsolete in the future. Shopping malls are a good example.

Photo AdobeStock

indicates one thing: increasing density and height. It does not matter whether someone sees their neighbor's wall or a dumpster from their window. The building exists to extract the maximum financial value from every square meter. This is very difficult to stop, and I dare say that we should simply prohibit the construction of new buildings to redirect the investment momentum toward enhancing, modernizing, and transforming existing structures," proposes Prof. Zielonko-Jung. "This would be a bold move, though I am certain it would meet significant resistance."

Why such a radical position? "I believe that without radical actions, we will not accelerate development in any direction," the professor concludes resolutely.

"Some actions may seem radical, but we at least need to talk about them. That does not mean immediate implementation," tones down Robert Skrzypczyński, PhD, Eng. "I think many of us are afraid to say things that might be perceived as radical, because we do not want to experience what the authors of *The Limits to Growth* did. I wish we would delve deeper into problems in public debate, discussing matters that might seem difficult to implement today but must be part of the discussion so we do not remain on the surface of the issue," reflects Robert Skrzypczyński, PhD, Eng.

"Today, to address the challenges of climate change, sustainable development, energy efficiency, and social problems, the knowledge and cooperation of many specialists are required," says Prof. Zielonko-Jung. "This must be a roundtable—a multidisciplinary discussion encompassing many conflicting viewpoints."

THE ENGINEER OF THE FUTURE AND THEIR ROLE

The role of designers in major planning processes is worth examining. What should the engineer of the future be like? What can they do regarding sustainable development within the scope of their roles and competencies?

"On the one hand, the easiest option is to say that we design according to the client's commission, and that is all," says Robert Skrzypczyński, PhD, Eng. "But I always try to raise the discussion in class or conversations like this one—can we really not do more? Do we not also have an advisory role? We can suggest alternatives or even giving up certain solutions. I think we can negotiate between being the contractors and keeping the contracts. Still, I believe we have a role in the public debate, and I always encourage students not to relinquish that role. For instance, to propose legislative changes. I think few of us learned this during our studies, but we, as an industry, can propose changes in legislation and speak up more boldly," encourages Doctor Skrzypczyński.

Photo Agata Cymanowska

> Theoretically, we know what must be done to improve urban conditions, but in practice, economic imperatives often overpower all other trends and challenges.

"Education in this spirit is necessary. Without it, there will be no understanding of the problem, and that understanding is the foundation for action," says Prof. Zielonko-Jung. "However, I must admit that as a teacher of future architects, I have mixed feelings because I know what awaits young graduates. They will enter the job market with ideals that will be immediately curtailed or even ridiculed. They will join offices where they are told to meet investor requirements based on profit, not social or environmental values. Either you design accordingly, or you are out."

"Fortunately, there is a growing number of young independent studios trying to operate differently, but they still constitute a very small proportion," offers a different perspective Prof. Zielonko-Jung. "Nonetheless, environmental awareness is gradually becoming more necessary and expected of architects, especially as building regulations are becoming stricter. This has already occurred in terms of energy use, and we can expect similar tightening in the case of carbon footprint. Therefore, competencies in project optimization in this respect are needed. Offices often rely on young professionals for their up-to-date education and proficiency with design-support software. Universities should equip students with such competencies, though it is not easy. The architect of the future no longer works with a pencil and tracing paper but uses specialized software for data modeling and microclimatic simulations. They should be familiar with 3D printing and innovative building materials. This requires investment in technical infrastructure of the university and specialized academic staff. Unfortunately, higher education and science in Poland are underfunded compared to other European countries," emphasizes Prof. Zielonko-Jung.

SCIENCE VS. PRACTICE

"There is, of course, a wide range of educational topics and engineering competencies. I try to draw attention to the design of the land use life cycle," says Robert Skrzypczyński, PhD, Eng., giving an example of his research. "And this is not just about a building, which requires materials and energy. Naturally, we need to obtain these materials from somewhere, and something will happen to them once the building is transformed or demo-

Robert Skrzypczyński, PhD, Eng.
Department of Urban Design and Regional Planning, Faculty of Architecture

Katarzyna Zielonko-Jung, PhD, DSc, Eng. of Architecture, Professor at Gdańsk Tech
Department of Environmental Design, Faculty of Architecture

Aleksander Orłowski, PhD, DSc, Eng., Professor at Gdańsk Tech
Department of Management, Faculty of Management and Economics

lished a hundred years from now. We should take a similar approach to land. The planning system should include an additional layer that defines the resource framework for land use across its entire life cycle. At present, we do not estimate what types of resource demands a given land use will generate. Yet I believe we should establish such frameworks, just as we do for volume or other parameters of structures that can be built on a given plot. So, without a systemic revolution, some improvements can be made—but, unfortunately, I fear that this will not be sufficient," he concludes.

"In my view, two things are particularly important today and not as self-evident as they might seem, especially when we consider what young people actually know," adds Prof. Orłowski. "We must demonstrate to the university's surrounding environment that what we do is practical and useful—that it is not merely theoretical. I take the position that science should be maximally useful, particularly in the field of management. Much of our scientific output exists for its own sake. Science has significantly drifted away from practice. Collaboration should be understood as a process—not one in which business approaches the university, but one in which university representatives understand the realities of business. This is difficult in both directions, but without such mutual understanding, we will continue to hear two distinct voices, where the university's voice will be weaker due to its limited agency when disconnected from market realities," argues Prof. Orłowski.

"In my opinion, the university is accountable first and foremost to society, and only then to individual stakeholders, who are, of course, also part of society—such as businesses or local governments," adds Robert Skrzypczyński, PhD, Eng. "I see the mission of the university primarily as fostering critical thinking among its graduates. Of course, the ability to acquire knowledge and think logically is also essential, but, in my view, assuming the role of social leaders is at least as important as acquiring professional skills," he continues.

"I believe that business would prefer to educate individuals who are useful to business," says Robert Skrzypczyński, PhD, Eng. "If I were in business, I would likely think the same. However, I feel that our primary responsibility to the political community and society—and within that, naturally, to business as part of this community—is to broaden students' intellectual horizons in social, environmental, and economic matters," he concludes.

"I support the practical dimension of science," joins Prof. Katarzyna Zielonko-Jung. "However, I would emphasize the ethical dimension. What does 'better' mean today? Better for the individual or for business? Better for the private investor or the community? Better in the short term or the long term? 'Better' can mean different things. The criteria behind design decisions can vary, which is why shaping students' ethical attitudes is so important. And this represents a significant educational challenge in today's world, which is full of crises, conflicts, power struggles, and aggression," she adds.

"I fully agree. The university's role is only partly about providing knowledge—it is also about shaping social attitudes and presenting a broader perspective," concurs Prof. Aleksander Orłowski."Everyone sees only the fragment they are involved with. A developer carries out a single project and does what is legally permitted. The question is how we can influence this and present a wider view? To me, it is incredibly important to show our students this broader perspective."

"What always brings me joy," Prof. Orłowski continues, "when I look at the young people who come to our university, is that they have a lot of energy and willingness to act. In fact, they do not necessarily need to be taught to act differently. Sometimes, they just need to be shown what has worked so far. Fortunately, there is no shortage of that energy, and that is something wonderful to end one's studies with—because it is a great asset," he concludes.

■ Katarzyna Michałowska


GDAŃSK TECH