

The fourth-generation model of Eindhoven University of Technology (The Netherlands): Recommendations for Algerian universities.

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Abstract:

The objective of this study is to highlight the strategy employed by the Eindhoven University of Technology in the Netherlands to its transformation into a fourth-generation university. A descriptive and analytical approach was adopted, resulting in the identification of several key findings include: the university's reliance on local and international partnerships, valorization of faculty members and students intellectual property, and its adoption of a lifelong learning policy. This enabled the university to develop quality digital innovations that contributed to develop solutions to economic and social problems.

Keywords: Fourth-Generation University; Intellectual Property; Lifelong Learning; Digital Innovations.

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1. INTRODUCTION

Technological developments and innovations have brought about significant changes in various sectors, including higher education. This sector plays a pivotal role in driving development by preparing a workforce with the requisite knowledge and skills for an increasingly technological age. Furthermore, universities act as a conduit for innovations and inventions that facilitate digital development.

In the context of the fourth industrial revolution, universities are seeking to enhance their competitive position at the local and international levels. Eindhoven University of Technology is one of the foremost universities in the Netherlands that has devised a strategic plan to maintain pace with international universities and attain a position that ensures sustainability and competitiveness.

In light of the aforementioned considerations, we pose the following research question:

What is the strategic approach that Eindhoven University of Technology has adopted to achieve its transition towards the fourth generation?

In order to gain a deeper understanding of the subject matter, we formulated the following sub-questions:

- What are the defining characteristics of a fourth-generation university?
- What are the outcomes of the fundamental tenets on which Eindhoven University of Technology based its strategy?

In order to answer the sub-questions and the main question, the study was divided into two axes. In the first axis we reviewed the basic concepts about the fourth-generation university and its main characteristics. As for the second axis, we looked at the most important elements that the university

under study relied on to keep pace with the fourth-generation universities and the results of their policies.

2. Concept of the university 4.0:

2.1 Definition of 'University 4.0':

The term 'University 4.0' is used to denote the transformation of higher education that is being driven by technological advancements and the digitalisation of university institutions. Drawing inspiration from the industry 4.0 paradigm, University 4.0 integrates advanced technologies with the objective of catering to the individual needs of students, emphasising continuous, digital, and personalised education models. This paradigm shift signifies a departure from conventional, rigid educational frameworks towards more flexible and adaptable learning environments. (Akturk, Talan, & Cubukcu Cerasi, 2022)

The fourth generation of universities is one that places an emphasis on the creation of societal value within the regional innovation ecosystem. It is responsible for the formulation of regional growth and prosperity strategies, the establishment of industry partnerships, and the strategic focus on key enabling technologies that are essential for the continued evolution of the ecosystem. Moreover, it is at the vanguard of pioneering new forms of education and research, including challenge-based learning and mission-driven research. (A Science/ Business Special Report, 2024)

A fourth-generation university is a dynamic university that interacts with the surrounding environment through three methods: namely, knowledge transfer (which constitutes the mission of education), knowledge creation (which constitutes the mission of scientific research), and knowledge application (which constitutes the mission of societal service). Furthermore, these methods necessitate a shift in leadership approach, both at the local and international levels. They also require a commitment to innovation and creativity. Furthermore, they assist in the identification of unconventional self-financing sources by marketing products within long-term relationships between educational institutions, governmental sectors, business units, and

non-profit organisations. This enables the creation of a flow of benefits to stakeholders at the domestic, regional, and international levels. (Wagdi, Abouzei, & Fathy, 2021)

The characteristics of fourth-generation universities are based on four dimensions: the achievement of the goal of education and research within the framework of multilateral innovation to create value; the development of human capital from professionals, scientists, entrepreneurs and others; the orientation of the university towards the ecosystem; the organisation of innovation spaces; and the support of the English language. (Garretsen, van de Goor, & van de Mheen, 2023)

2.2 The defining characteristics of a fourth-generation university:

Fourth-generation universities are distinguished by a number of characteristics that enhance their reputation and make them a key focus on economic and social issues. These features position fourth-generation universities at the forefront of universities that integrate digital transformation, global cooperation, and flexible education models that align with the needs of society and the workforce.

➤ The process of adopting digitisation:

Fourth-generation universities adopt digitisation through the implementation of digital training for all employees. This enables the development of competencies in a range of areas, including hardware, information, software, security, innovation, and systems. Additionally, a focus is placed on fostering creativity, independence, trust, cooperation, and integrity.

Perhaps the most significant challenge confronting universities in their transition towards digitisation is the absence of a clearly defined vision for digital transformation, the substantial financial requirements, and the dearth of digital skills, in addition to the lack of understanding of privacy, security, digital standards, and collaborative solutions. Furthermore, the resistance to change from the traditional university to the modern university must be acknowledged. (Wagdi, Abouzei, & Fathy, 2021)

➤ **Material preparations:**

In order to facilitate the transformation and development of universities, it is essential to provide the necessary funding to equip classrooms with the requisite technology, including internet access, smart boards, audio-visual equipment, and motion recognition software. In addition to these collective resources, it is also vital to provide individual devices for faculty and students, such as tablets or laptops equipped with specific applications designed to enhance learning and facilitate data analysis.

➤ **Training in soft skills:**

The value of soft skills training in higher education can be attributed to several key factors, including: (Salehi, Mohammadi, Ahmadian, & Khanlarzadeh, 2021)

- Problem solving: the capacity to analyse and resolve issues in an effective manner.
- Creativity: the capacity to generate novel ideas and solutions.
- The effective utilisation of available resources, including tools and materials.
- Teamwork: the capacity to collaborate effectively with diverse teams.
- Listening: the ability to listen effectively in order to comprehend and respond appropriately.
- Management: the ability to organise and direct efforts towards the achievement of defined goals.

However, there are obstacles to integrating soft skills training into the curriculum, as universities tend to prioritize technical expertise (e.g., laboratory and clinical training), which results in a deficiency in the cultivation of soft skills. Consequently, graduates frequently exhibit deficiencies in the personal and cognitive abilities necessary for success in contemporary and dynamic workplaces.

➤ **Teaching and learning innovations:**

Generation 4.0 universities require flexible and supportive digital environments, including blended learning, virtual learning, game-based

learning, and project-based curricula. Additionally, open platforms such as edX are necessary for students to complete courses and acquire skills flexibly. Autonomy is also a key aspect, allowing students to choose educational paths, resources, and assessment schedules.

➤ **Scientific Research Focus:**

Generation 4.0 universities are committed to scientific research, with a particular emphasis on the timeliness and relevance of research projects, the promotion of global, collaborative and innovative research, and the ethical implications of new technologies, including the ethics of artificial intelligence.

➤ **Internationalization:**

The process of making a product, service, or concept accessible to and usable by individuals from other countries is known as internationalisation.

The concept of internationalisation encompasses a range of initiatives, including joint degree programmes and international collaboration, the integration of e-learning and site-based programmes through a blended learning approach, and the incorporation of international research and community engagement.

➤ **Lifelong Learning:**

The concept of lifelong learning is a fundamental tenet of contemporary education.

Generation 4.0 universities facilitate continuous education through flexible and adaptable structures, offering students the opportunity to re-enroll in programmes at various points throughout their careers, with the aim of enhancing their existing skills or acquiring new ones.

The ongoing technological transformation and economic shifts are creating an increasingly pressing necessity to guarantee that growth is both inclusive and equitably distributed. In response to these trends, there is a clear imperative for a heightened emphasis on socially inclusive lifelong learning.

This necessitates the provision of cognitive abilities and knowledge, acquired through academic or vocational training, to a greater number of individuals, whilst ensuring equitable distribution of soft skills, such as resilience and confidence, which are becoming increasingly crucial for success in the workplace and for broader life outcomes. (James, Sadik, & Brown, December 2021)

The subsequent figure illustrates the strategies that could be employed to develop a fourth-generation university.

Figure 1: Strategies for Fourth-Generation Universities



Source: prepared by the researchers based on: Salehi, A. M. and al, (2021 December), Move to the Fourth-Generation Universities: A Systematic Scoping Review of Educational and Management Strategies, Strides Dev Med Educ.; 18(1), pp 3-9.

3. Eindhoven University of Technology towards the 4th generation:

Eindhoven University of Technology (TU/e) exemplifies the fourth-generation university model, which is distinguished by a commitment to innovation and community development within the surrounding region. The

university has identified flexibility, collaboration and talent development as its key priorities.

Table 1: Strategic Priorities 2025 of Eindhoven University of Technology

RESILIENCE	COOPERATION
- Transforming the campus into a vibrant and attractive destination for students, scientists, entrepreneurs, researchers and companies, with creating an environment in which people feel safe, welcomed and inspired. - Achieve high ambitions for education and research through digitisation, ensuring security, state-of-the-art technology and innovation. - Supporting primary processes and empowering professional staff - Deliver services from within a quality culture of continuous improvement and customer-oriented approach - Leading the change towards 2030 with strengthening true partnership between scientific and professional staff - Establishing an academic environment characterised by safety and inclusivity, adhering to rigorous ethical standards.	- The enhancement of the reputation and visibility of the university as a preeminent centre for education and research at both the European and global levels. - The consolidation of collaborative efforts with primary partners within the regional context. - Enhance the collaboration with strategic partners within the Utrecht-Wageningen-Eindhoven alliance, as well as with other universities in the Netherlands. - Heightening collaborative endeavours at both the European and global levels, in conjunction with eminent partners from the realms of science and industry, and engaging in significant funding initiatives and programmes. - Promote the influence on both the region and society at large through the medium of researchers, graduates, and research findings.

Source: TU/e institutional plan 2020-2025, (February 2021), leading the change, Eindhoven University of Technology, pp 20-21.

Figure 2: goals of cooperation

Figure 3: goals of resilience



source: prepared by the researchers based on table n° 2

3.1 The fostering of local and international cooperation:

➤ Joint research with industry:

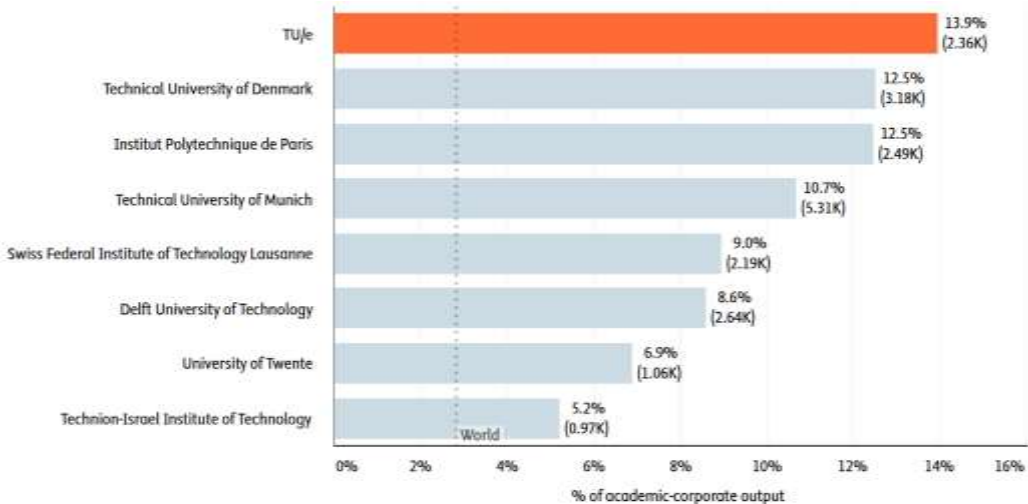
The undertaking of joint research projects with industry partners represents a significant aspect of the research activities conducted at this university.

The collaborative research output between academia and industry partners is an important indicator of a university's capacity to integrate theoretical knowledge with practical applications, thereby fostering innovation and technological advancement. Such synergy serves not only to enhance the relevance and applicability of research outcomes, but also to stimulate economic growth and address societal challenges.

The following figure illustrates the extent to which universities engage in research collaboration with industry, as indicated by the total share of academic-institutional output at TU/e.

TU/e is distinguished by the highest proportion of academic-institutional publications as a percentage of its total research output. Furthermore, all comparable institutions exceed the global average of 2.7% in terms of the share of academic-institutional collaboration, thereby demonstrating a commitment to fostering partnerships with industry. (Malkov, Dumoulin, & Westenbrink, 2024)

Figure 4: Share of academic–corporate output (2018–2022)



Source: Malkov, D., Dumoulin, M., Westenbrink, R., (2024), Towards the 4th generation university, the transformative role of TU/e in delivering innovation and impact in the Eindhoven region, Elsevier, TU/e, p 23.

➤ **International cooperation:**

Strategic alliances with esteemed partners, such as the EuroTech University Alliance, are leveraged to enhance the reputation of TU/e and expand the scope of industrial relationships.

In order to succeed in pursuing European collaborative opportunities and to secure the necessary financial resources, it is essential to have access to professional and effective support. TU/e is implementing a Research Support Network at the departmental and institutional levels, and is providing dedicated assistance with the application of personal grants.

At the international level, the EuroTeQ alliance, an education-specific component of the broader EuroTech alliance, serves to consolidate strengths with like-minded and comparable European universities of technology. The objective

of this alliance is to investigate the various possibilities for international collaboration with a unified vision on the education of engineers of the future. This affords students and faculty the opportunity to gain experience of working in an international environment, both virtually and physically. (Lopez-Arteaga, Koenraad, & Rijk, 2023)

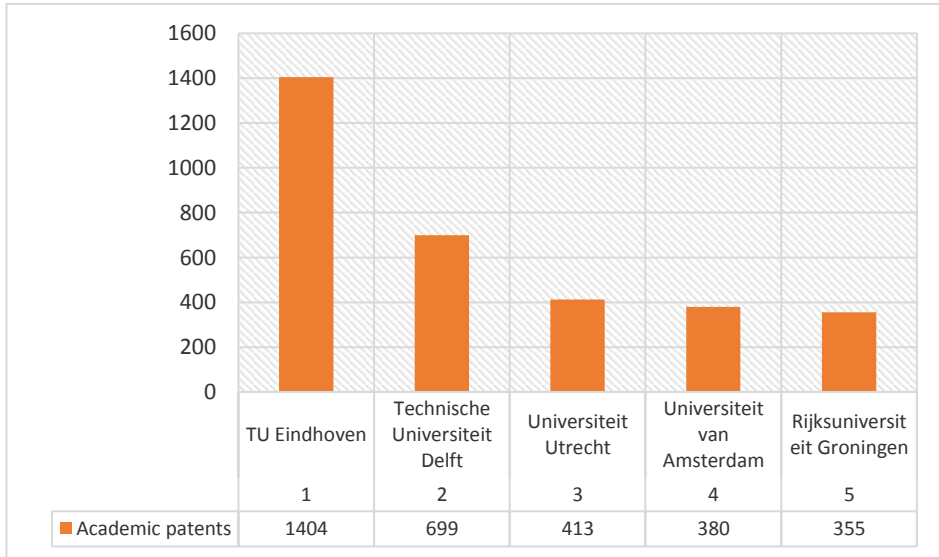
The EuroTech Universities Alliance is an association of academic institutions that are at the forefront of research in the fields of science and technology. The alliance comprises the following institutions: the Technical University of Denmark, the École Polytechnique Fédérale de Lausanne, the École Polytechnique, Eindhoven University of Technology and the Technical University of Munich. (Eindhoven University of Technology, February 2021)

The European Universities scheme is widely regarded as one of the European Commission's most prestigious funding programmes. The instrument's objective is the establishment of a collection of ambitious European university alliances over the course of the next few years, with the intention of reinforcing the European university landscape. The European Union is providing financial support to EuroTeQ as part of its European Universities programme. The investment from the Erasmus+ initiative is approximately five million euros, while the contribution from the Horizon 2020 programme is two million euros. (EuroTeQ Engineering University, 2023)

3.2 Intellectual Property Rights, Usage Rights and Incentives:

Eindhoven University of Technology has established provisions regarding intellectual property rights for both its faculty members and its students. In circumstances where a research endeavour is funded by external entities (e.g., grants, contract research), or if it constitutes a collaborative research initiative, the ownership of intellectual property rights will be regulated in accordance with the terms of the agreement drawn up between the university and the external parties, following consultation with the Research Support Organisation (RSO) and the Gate.

Figure 5: Academic patents in the Netherlands universities (2000–2020)

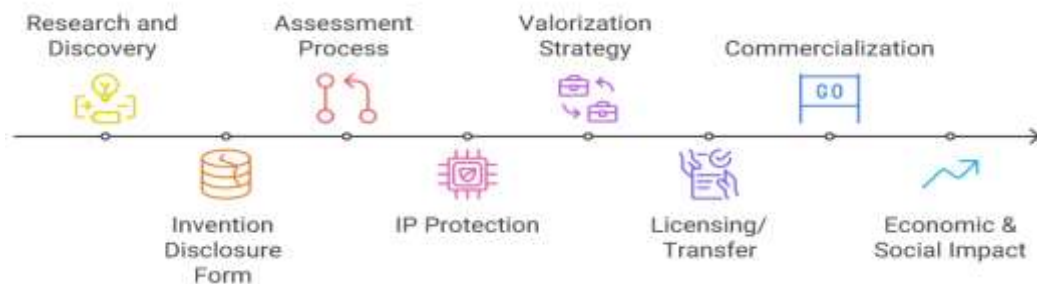


Source: Prepared by the researchers based on: Ménière, Y. and al, the role of European universities in patenting and innovation, (October 2024), European Patent Office, Munich, p 78.

Eindhoven University of Technology has devised a systematic framework for offering incentives to researchers and innovators, with the objective of fostering research with a social and economic impact and promoting the commercialisation of knowledge. The approach encompasses both pecuniary rewards and other incentives. A total of 33⅓% is apportioned to the inventors. Proportional distribution is applied to the inventors. An additional 33.33% is allocated to the inventors' group or department. Financial assistance is provided for the initiation of new research activities within the pertinent department(s). The remaining 33.33% is allocated to the Patent Fund of the Technical University. It offers assistance with regard to patents and intellectual property initiatives. The aforementioned distribution methodology is applicable to faculty members. In the case of students, the ownership and distribution of intellectual property is contingent upon the terms of specific agreements or policies. (Eindhoven University of Technology, The gate, 2022)

The process of knowledge valorization is summarized in the figure that follow.

Figure 6: The knowledge valorization process



Source: prepared by the researchers based on: Knowledge Valorization, (October 2022), Eindhoven University of Technology, The gate, Eindhoven, p 4.

3.3 The output of Creativity and innovation:

Four universities of technology in the Netherlands, including TU/e, offer technological designer programmes known as EngD (Engineering Doctorate). These programmes enable students to develop the competencies required for synthesis and interdisciplinary work. The solutions developed by EngD students are based on both functional requirements and business and market requirements, as well as on the broader context of society.

In response to the advent of Professional Doctorate (PD) pathways at the Universities of Applied Science in the Netherlands, the four TU's resolved to transition from the degree PDEng to Engineering Doctorate (EngD) on 1 September 2022. The four universities of technology in the Netherlands offer programmes of study at the doctoral level in the field of technological design. These programmes are referred to as EngD programmes.

Eindhoven University of Technology in the Netherlands is committed to making a significant contribution to regional development while simultaneously maintaining robust international partnerships. Notably, 80% of the university's Dutch master's students and 62% of its international

students choose to remain in the region after graduation. This constitutes a highly robust indicator of the contribution made to the local innovation ecosystem. (A Science/ Business Special Report, 2024)

The societal challenges of health, energy and smart mobility serve as the primary impetus for TU/e's research activities. The research institutes that form part of the TU/e research ecosystem, including the Eindhoven Artificial Intelligence Systems Institute, the Eindhoven Institute for Renewable Energy Systems, the Institute for Complex Molecular Systems and the Eindhoven Hendrik Casimir Institute, work to match the university's strengths with the strategic priorities of industry and government. (EuroTeQ Engineering University, 2023)

Table 2: Projects of EngD trainees in Eindhoven University of Technology

Project	The field	Goal
Virtual Unaging of Van Gogh's Paintings	Automotive Systems Design	Digitally reconstruct the original colors of paintings by Vincent van Gogh using AI as part of the Engineering Doctorate in Automotive Systems Design Program.
Enhancing the utilisation of clinical guidelines at the Prinses Máxima Center for Paediatric Oncology by the standardisation and formalisation of computer-interpretable guidelines	Clinical Informatics	- Design and progress a scalable approach to standardise and formalise text clinical guidelines in computer interpretable guidelines and utilise them in a Clinical Decision Support System. - Design an information model that accurately represents the structure of guidelines and facilitates in the translation process. - A sustainable, shareable, scalable, interoperable, cost-effective solution could be designed for implementation in other hospitals.
Sustainable business model to facilitate the conception of public value	Smart Building and Cities	The fields of innovation management and human-computer interaction have been integrated through the provision of a prototype digital platform, which has been developed with the financial support of TU/e BOOST in order to facilitate the

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within living lab innovation ecosystems.		implementation of a business model that encompasses the following elements: 1) The value proposition of the Living Lab. 2) The realization of the ecosystem's value proposition is contingent upon the execution of all designated activities. 3) Participation from all designated actors or personas is required to successfully carry out the defined activities. 4) Coordinate the efforts and manage the expectations of all the actors by governance model and mechanisms. 5) Linking activities and actors through the business model structure.
The utilisation of AI in the design of a Learning Health System that fosters perpetual learning from data and clinical practice.	Clinical Informatics	The University Medical Center Groningen adopted a Learning Health System approach with the objective of providing comprehensive support to healthcare professionals, ensuring the provision of the correct information to the relevant individuals at the optimum time which are used to support the decision-making process.
Predict energy consumption for battery electric buses and involve the design, implementation and validation of a cloud-based software.	Automotive Systems Design	The 'Destination Zero!' project facilitates the estimation of the residual battery charge when the vehicle arrives at the charger. The following methodology may be employed to enhance the operational process: - It can be driven for a greater number of trips before requiring recharging, or alternatively, for the same number of trips but with a smaller battery capacity. - The precise determination of the quantity of energy required for a complete recharge.

Source: prepared by the researchers based on:

- Innovative solutions designed by EngD trainees, (2022), 4TU. School for Technological Design stan Ackermans institute, pp 4-15.

- Innovative solutions designed by EngD trainees, (2023), 4TU. School for Technological Design stan Ackermans institute, pp 7-10.

Since 2022, a number of student teams from TU/e have been operating under the aegis of the TU/e Innovation Space, achieving notable success in terms of impact and reputation. Their achievements include: (Technische Universiteit Eindhoven, 2022)

- TU/ecomotive concluded their 11,000-mile, six-week coast-to-coast (and back) tour of the United States with their CO₂-capturing, ultra-sustainable concept sports car, ZEM. The tour was disseminated through media outlets in over 50 countries, reaching an audience of over 400 million.

- The iGEM Eindhoven team was victorious in the global iGEM competition in the Bachelor category, competing against over 180 teams.

Team VIRTU/e attained the runner-up position in the three-year Solar Decathlon built environment competition in Wuppertal with their flexible living concept, designated as 'Ripple'.

- Tech United, the combined team of students and TU/e employees, became world champions in both soccer robots and service robots.

- Aristoteles Technologies, the developer of cognitive training systems for top athletes, received funding from an angel investor to expand their product range to new market segments.

3.4 lifelong learning:

The process of lifelong learning commences at the outset of their bachelor's degree programme for students of (TU/e). The programme is designed to impart the skills and mindset essential for sustained engagement in lifelong learning. This enables the students to engage in a reflection on their learning process and outcomes, as well as the development of their knowledge and skills. They are capable of determining their individual learning needs and identifying the most appropriate strategies to address these needs. (Lopez-Arteaga, Koenraad, & Rijk, 2023)

4. Conclusion:

The study in question indicates that Eindhoven University of Technology has developed a roadmap for the transition to the fourth generation of universities and has become one of the most important universities in the Netherlands and other European countries. The university has concentrated its efforts on establishing collaborative relationships with other academic institutions abroad, enabling its students and faculty to gain international experience and expertise.

The collaboration between Eindhoven University of Technology and Industry represents a significant catalyst for the advancement of students' personal competencies, prompting them to devise digital solutions to address existing challenges that benefit the economy and society. The university's commitment to transparency and reputation management has reinforced its global standing, establishing it as a leading institution in the pursuit of the 2030 Sustainable Development Agenda.

Eindhoven University of Technology has adopted a strategy of lifelong learning with the objective of attracting and harnessing talent and skills in order to achieve competitiveness, both for the university and for the economy as a whole.

Recommendations:

The Algerian Ministry of Higher Education and Scientific Research has announced the establishment of a national committee with the remit to monitor and evaluate higher education institutions in their transition to University 4.0. This announcement was made in a ministerial decision dated 19 January 2025, and represents a significant step towards the digital transformation, technological integration and innovation-based education models.

The findings of our study allow us to propose a series of recommendations for the development of Algerian universities, which must

adapt to the technological developments of the Fourth Industrial Revolution, also known as "Technology 4.0" by:

- Forming genuine collaborative relationships with local and international academic institutions, both Arab and foreign, with the objective of supporting scientific research with economic and social impact;
- Constructing a framework that defines the means of benefiting from the marketing of academic patents;
- It is incumbent upon universities to provide students with a balanced education that encompasses both technical and soft skills training. This is necessary in order to prepare students for the modern workforce, where adaptability, communication, and creativity are as important as technical proficiency;
- Develop workshops and courses focusing on leadership, communication, and critical thinking;
- Multidisciplinary collaboration be fostered by encouraging teamwork across different fields, with a view to improving adaptability and collaborative problem-solving;
- It is of paramount importance to establish a regional technological ecosystem with a view to facilitating the growth of the next generation of university graduates.
- Develop of university scientific laboratories, increase of government funding for scientific research, and the pursuit of alternative funding sources through the enhancement of partnerships with economic companies.

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