CHALLENGES IN TRAINING AND RESEARCH IN ELECTRONICS, SEMICONDUCTOR AND MICROCHIP TECHNOLOGY AT UNIVERSITIES IN VIETNAM

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ABSTRACT

Vietnam currently has a significant opportunity to deeply participate in the value chain and supply chain of high-tech industries, particularly related to electronics engineering, semiconductor and microelectronics [7]. Faced with the enormous demand for high-quality human resources in the field of microchip design and the semiconductor industry in the word and in Vietnam, our technical universities must engage in the training process. This article discusses the development trends of the semiconductor industry in Vietnam and the world, providing a preliminary analysis of society's demand for microchip design human resources, thereby highlighting the urgent need for high-quality human resource training in this field. Additionally, the article addresses the challenges faced by Vietnamese universities in training and research in semiconductor electronics and microchip technology. The author also proposes several recommendations and solutions to help Vietnamese universities meet the high-quality human resource training requirements in microchip design and semiconductors.

Keyword: *IC design, microchip, microelectronics, semiconductor industry, high-quality human resources*

1. INTRODUCTION

Vietnam's workforce demand in the semiconductor–microchip field is forecast to be around 20,000 engineers for the next five years, and 50,000 engineers in the next 10 years, according to economists from the Fullbright University [3],[12]. Regarding Vietnam’s preparations for training high-quality human resources serving the semiconductor industry, Nguyen Thu Thuy, Director of the Higher Education Department under the Ministry of Education and Training, said the number of microchip designing engineers in the country is approximately 5,000 [12].

According to experts from technology universities, the demand for training human resources in this area in the coming years is expected to be around 3,000 engineers per year, with at least 30% of them being postgraduate graduates [3],[12]. Vietnam is home to over 50 foreign-invested enterprises that have invested in the microchip and semiconductor industry, with significant demand for high-quality human resources, especially in the field of microchip design [12].

In today's context, the semiconductor microchip industry is considered a “launchpad” for the development of the electronics industry as well as the overall economy. This manufacturing sector is currently facing both new opportunities and numerous difficulties and challenges [2], [5].

This paper points out some of the challenges in training and research in electronics, semiconductor and microchip technology at Vietnamese universities.

2. DEMAND FOR HIGH-QUALITY HUMAN RESOURCES IN MICROCHIP DESIGN AND THE SEMICONDUCTOR INDUSTRY

2.1 Development trends of the semiconductor industry in Vietnam and globally

Currently, Vietnam stands before a significant opportunity for development and deep participation in the value chain and supply chain of high-tech industries, particularly those related to semiconductor electronics and microchip. Vietnam is currently ranked 9th globally in electronics product exports, with a rapidly developing semiconductor ecosystem and the potential to enhance its position in the global semiconductor supply chain [7]. The Politburo's Resolution No. 23-NQ/TW dated March 22, 2018, on building policies for national industrial development until 2030, with a vision to 2045, identifies the development of semiconductor electronics and microelectronics as a primary path. The resolution sets a goal that by 2030, these industries will reach an advanced global level, meeting the requirements of the Fourth Industrial Revolution and creating a digital technology foundation for other industries. This path is similar to the industrialization processes of East Asian countries like Japan, South Korea, Taiwan, and recently China [5,6].

The recent visit of USA President Joe Biden to Vietnam marked an upgrade in bilateral relations to a comprehensive strategic partnership. This move is expected to further boost economic development in both countries, with cooperation in science, technology, and innovation being a breakthrough step. Vietnam's high-tech economic development orientation aligns with the US's strategy to shape regional supply chains [4]. Key areas of economic cooperation between Vietnam and the US, such as semiconductor electronics and microchip, can attract substantial foreign investment and development. Technology corporations like Intel, Amkor, Marvell Technology, Faraday Technology, Renesas Corp., Synopsys, Cadence, Keysight Technology, Global Foundries, and the US Semiconductor Industry Association will collaborate with the National Innovation Center (NIC) to build a research and development training center to eventually semiconductor chip design products in Vietnam [8].

At the Vietnam Human Resources and Technology Conference held on September 15 in Hanoi, the Vietnam Software and IT Services Association (VINASA) highlighted some notable figures. Vietnam lacks 150,000-200,000 human resources in the semiconductor, electronics field from 2022-2025. According to Bloomberg, Vietnam is one of the top four Asian countries exporting semiconductor chips to the US, with sales exceeding $500 million in February 2023. This indicates Vietnam's significant potential to become a major chip-producing country globally; however, addressing the human resource shortage is crucial. Faced with this challenge, in Resolution 124 NQ/CP concluding the content of the Government's regular meeting in July 2023, the Vietnamese Government assigned ministries to quickly develop and implement a plan to develop 30,000 to 50,000 human resources by 2030 in semiconductor electronics sectors to supply personnel for Vietnam's high-tech industries [6].

Vietnam has many opportunities in the semiconductor and microchip field as companies tend to shift and increase investments in Vietnam, especially after the recent visit of US President Joe Biden, which also demonstrated Vietnam's international recognition (*according to Mr. Ray Nguyen - Director of Analog and Mixed-Signal Design at Marvell Technology, USA*).

2.2 Human resource demand in microchip design and semiconductors field

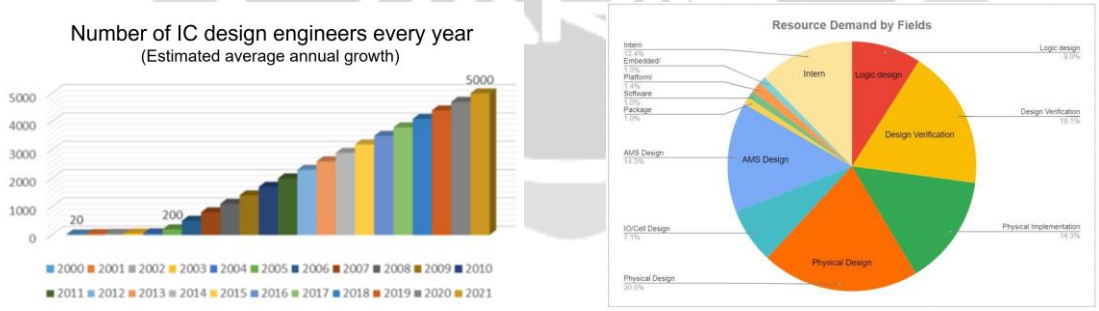
According to a survey by the Ho Chi Minh City Semiconductor Industry Association (HSIA), from 2019 to now, Vietnam needs about 1,000 microchip design engineers annually. Overall, Vietnamese universities still cannot meet the human resource demand in this field. Therefore, promoting the training of microchip engineers is extremely necessary. In the semiconductor supply chain, which includes four stages: design, production, packaging - testing, and equipment manufacturing [2]. According to experts from technology universities, the demand for training human resources in this area in the coming years is expected to be around 3,000 engineers per year, with at least 30% of them being postgraduate graduates [12]. Vietnam currently has an advantage in participating deeply in the design stage, which accounts for 53% of the added value of a microchip product. Many large microchip design companies in the world are present in Vietnam, creating a high demand for high-quality human resources. Developing microchip technology with domestic resources requires solving the human resource problem first and

having a national-level strategy (according to Assoc. Prof. Dr. Mai Thanh Phong - Rector of Ho Chi Minh City University of Technology).

Currently, over 50 large FDI enterprises have invested in Vietnam in the semiconductor and microelectronics industry (Saigon Hi-Tech Park, Intel, Marvell Technology, Faraday Technology, Renesas Corp., Synopsys, Cadence, Keysight Technology, Wavepia Inc., Rainno, IMEC, NXP, Ampere Computing, FPT, and Viettel...), with significant demand for high-quality human resources, especially in the field of microchip design. The microchip design field requires the highest number of high-quality human resources. It is expected that after the US President's visit, more large corporations will invest in Vietnam, mainly requiring human resources in microchip design, with hopes for investments in production industries [11].

Fig -1 : Microchip design companies in Vietnam [1]
(*according to the Vietnam Microchip Community - data of October 2023*)

The total human resource demand in this field is projected by some economic experts (Fulbright University) to be about 20,000 in the next five years and about 50,000 in the next ten years from the university level or higher. Currently, there are about 5,000 IC design people in Vietnam, according to industry insiders (from technical universities). The training demand in the coming years is about 3,000 people/year (consistent with economic experts' forecasts), with at least 30% of graduates being at the postgraduate level (including level 7 engineers, masters, and PhDs). The demand for human resources to develop the semiconductor and microchip design industry increases by 10-15% annually, but there is still a shortage in both quantity and quality. Most of these human resources are only design engineers (physical design, layout design) and testing (Design Verification - DV).



a) Estimated number of chip design engineers in Vietnam in the period 2000-2021

b) Ratio of human resource distribution in all stages of the semiconductor industry and IC design in Vietnam

Fig -2: Estimated number of chip design engineers in Vietnam from 2000-2021 and the distribution ratio of human resources in the stages of the semiconductor industry and chip design in Vietnam [1].

Companies in the semiconductor and microchip design field in Vietnam currently have about 150 new recruitment positions quarterly since 2021, mainly focusing on some key stages in the chip design process (Physical Design: ~20%; Design Verification: ~18%; Design Implementation & AMS Design: ~14%) [1].

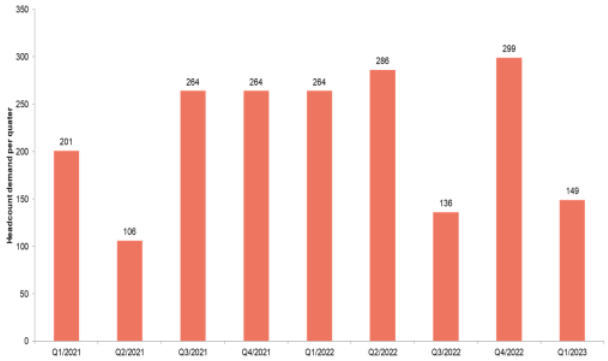


Fig -3: Number of new recruitment positions quarterly of companies in the semiconductor and microchip design field since 2021 [1].

2.3 Training high-level human resources (Engineers, Masters, Doctorates) for semiconductor industry development

The microchip design process includes two main stages: "Front-end design" (logical design) and "Back-end design" (physical design). IC design engineers can immediately participate in the Back-end design stages like layout or microchip testing and some Front-end design for simple digital and analog microchips.

According to Mr. Nguyen Thanh Yen – Director of CoAsia Semi Vietnam Company, Administrator of the Vietnam Microchip Community, Vietnam should focus on developing fabless companies (specialized in designing semiconductor products) [9].

Training highly specialized human resources in microchip design is an important and urgent issue, especially recently, as microchips receive increasing attention from the government, businesses, and training institutions. Given the specific requirements of the microchip semiconductor industry, human resource training demands training institutions to have strong capacities and potentials in facilities, laboratories, training programs, teaching staff, and cooperation networks. Additionally, due to the unique nature of microchip design and research activities, modern and synchronized laboratory equipment systems are essential. Moreover, in the semiconductor industry development network, collaboration between domestic educational institutions, foreign training institutions, and enterprises is seen as a crucial factor to boost the research and training potential of both sides.

Currently, IC design and semiconductor microelectronics engineer training is concentrated in a few universities in Vietnam, primarily in some institutions like Ho Chi Minh City University of Technology - Vietnam National University Ho Chi Minh City (about 26%), Ho Chi Minh City University of Science – Vietnam National University Ho Chi Minh City (18%), Ho Chi Minh City University of Technology and Education (12%), Hanoi University of Science and Technology (9%), University of Information Technology – Vietnam National University Ho Chi Minh City (6%), DaNang University of Technology (6%) [1].

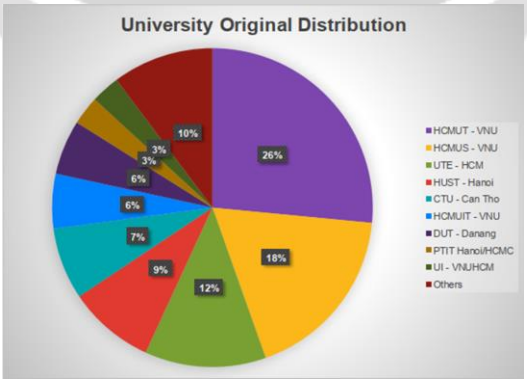


Fig -4: Distribution ratio of graduates in microchip and semiconductor fields from universities in Vietnam (according to the Vietnam Microchip Community and HSIA - Ho Chi Minh City Semiconductor Industry Association)

To anticipate the trend of providing labor resources in the semiconductor electronics and microchip industry with a vision to 2045, Thai Nguyen University of Technology (TNUT) proposes to establish a training program for Electronics, Semiconductors, and Microchips Technology, with the main focus on training technology engineers working in fields related to IC design and IC semiconductor manufacturing.

Thai Nguyen University of Technology, established in 1965, has accumulated 58 years of training experience, offering 37 undergraduate and postgraduate programs. These programs include fields such as Electronics and Telecommunications Engineering, Materials Engineering, Mechatronics, and Computer Engineering. In alignment with the functions and duties issued by the Ministry of Education and Training and Thai Nguyen University, the Thai Nguyen University of Technology is the suitable unit in Thai Nguyen University to develop and implement the enrollment and training programs in Electronics, Semiconductors, and Microchips Technology.

With the capacity and qualifications of full-time lecturers, the TNUT fully meets the conditions to train engineers in the field of Electronic, Semiconductor and Microchips Technology. The opening of the new major will meet the human resource needs for economic development of the country in general and the Northern midland and mountainous region, contributing to the development of the University and implementing the multidisciplinary training strategy, multi-disciplinary of Thai Nguyen University; realizing Resolution No. 23-NQ/TW dated March 22, 2018 of the Politburo on orientations for building national industrial development policies to 2030, vision to 2045.

3. CHALLENGES IN TRAINING AND RESEARCH IN ELECTRONICS, SEMICONDUCTOR AND MICROCHIPS TECHNOLOGY AT UNIVERSITIES IN VIETNAM

The semiconductor industry is becoming a potential industry with rapid growth globally. Vietnam is considered to have a fast-growing semiconductor ecosystem with the potential to enhance its position in the global supply chain.

At the same time, the fact that large corporations around the world have invested in Vietnam recently shows that Vietnam is facing a huge opportunity to develop the domestic semiconductor industry and enter the trillion-dollar global semiconductor market. Currently, there are two ways for Vietnam to develop the semiconductor industry, one is to expand the open manufacturing and production stages, and the other is to promote the design and packaging stages.

Factories in Vietnam are just stopping at being addresses for large corporations to carry out packaging and testing, there are no semiconductor chip manufactoring factories yet. “Chip production will require huge investment in infrastructure, machinery, etc. If large quantity production is not guaranteed, it will be almost unprofitable. While with chip design, the initial investment cost is many times lower and has a very high profit rate” (According to Mr. Nguyen Thanh Yen - Director of CoAsia Semi Vietnam Company, Administrator of Vietnam Microchip Community). With lower costs and certain advantages for human resource training, focusing on the design stage is considered a more appropriate option for Vietnam to develop the semiconductor industry [9].

Despite the participation of many large universities, training in the field of microchips and semiconductors in Vietnam is facing many difficulties and cannot immediately meet the great demand for quality human resources. high quality. Training high-quality human resources in the field of microchips and semiconductors at universities in Vietnam is currently facing many challenges, which can be listed as follows.

3.1 There is no code for microchip design majors, enrollment targets are dependent, and there is a lack of training programs and courses.

Training human resources in semiconductor technology and microchip design is relatively new in Vietnamese universities. Although it has received some attention, it still faces many limitations. Currently, only a few universities in Vietnam have formal programs specializing in microchip design and semiconductor technology. Some universities have only introduced this program in recent years, mainly focusing on the basic knowledge and applications in microchip design. The depth of knowledge and training for highly specialized engineers in microchip design and semiconductor technology is still limited.

The training program in microchip design and semiconductor technology in Vietnamese universities is not comprehensive and lacks depth. It mainly focuses on the basic knowledge, with less emphasis on the application and specialized training. The training content is mainly theoretical, with little focus on practical training and research. This limits students' ability to apply their knowledge in practice and limits their research capabilities in the field of semiconductor technology and microchip design.

Currently, almost a number of universities in Vietnam train human resources related to microchip design and semiconductor technology, almost exclusively in major groups such as Electrical & Electronics Engineering, Electronics and Telecommunications Engineering, Computer Engineering, Informatics, Technical Physics,... and a number of related and appropriate training majors such as Electrical and Electronics Engineering Technology, Automation and Control Engineering, Automation and Control Engineering Technology, Robotics Engineering and Artificial Intelligence, Computer Science, Information Technology, Microelectronics Engineering and Nanotechnology, Data Science, Information Systems , Applied Mathematics.

Currently, the Ministry of Education and Training still does not have a level 4 majors code for the microchip design majors (university and postgraduate systems). Enrollment quotas currently still depend on existing training majors. There are no specialized training programs in IC design as well as very few short-term training courses in IC design.

3.2 Lack of lecturers/experts specializing in IC design and semiconductor technology as well as appropriate support policies

The problem of shortage of lecturers and experts with experience in the field of IC design and semiconductor technology is one of the significant challenges for universities in Vietnam when participating in training in this field. The teaching staff in this field is still limited in both quantity and quality. Most of the lecturers have not been formally trained in microchip design and semiconductor technology. They mainly come from related fields such as electronics, telecommunications, and information technology. Therefore, their expertise and experience in microchip design and semiconductor technology are still limited.

The solution to solve this problem is to improve the quality of lecturers and orient lecturers to doctoral degrees in the field of IC design and semiconductor technology. In addition, it is also possible to attract well-trained Vietnamese experts working in foreign companies to teach and offer appropriate salaries [10].

3.3 Facilities and laboratories specializing in IC design and semiconductor technology are lacking or very poor, and have not kept up with the development of technology

One of the biggest challenges in training human for the semiconductor and microchip majors today is the lack of training infrastructure (according to Assoc. Prof. Dr. Do Van Dung, former Rector of Ho Chi Minh City University of Technology and Education). The facilities and equipment for training in microchip design and semiconductor technology in Vietnamese universities are still inadequate. Most of the laboratories are not equipped with modern and synchronized equipment systems. This limits students' ability to practice and conduct research in the field of semiconductor technology and microchip design [10]. The specialized software tools for practice, experimentation, and simulation in microchip design are all license and very costly.

3.4 Lacking a research center for microchip design that connects enterprises, universities, experts, and fabrication, testing practices, and verification

Currently, the level of connection between enterprises, schools, and the government is not strong enough, leading to superficial cooperation in guidance and training human. The cooperation between universities and enterprises in research and development in semiconductor technology and microchip design is still limited. Most of the research projects are carried out independently by universities, with little involvement from enterprises. This limits the application and commercialization of research results, as well as the ability to attract funding and investment for research activities. To improve this, the government needs to implement policies to attract and enhance collaboration between enterprises and universities.

Foreign companies often require the government to have tax reduction policies when supporting human resource training, but Vietnam currently does not have such policies. Moreover, for training, companies need mentors for students and expensive equipment, which requires financial support. Another major issue is that enterprises are concerned that students, once trained, may work for competitors, causing a brain drain. Therefore, many foreign semiconductor companies are quite listless to supporting human resource training in Vietnam, shared by Assoc. Prof. Dr. Do Van Dung.

Research activities in semiconductor technology and microchip design in Vietnamese universities are still limited. Most of the research is at a basic level, with little application and development of new technologies. The research results are mainly published in domestic journals, with few being published in international journals. This limits the visibility and impact of research activities in Vietnamese universities.

The funding for research activities in semiconductor technology and microchip design in Vietnamese universities is still limited. Most of the funding comes from the state budget, with little support from enterprises and international organizations. This limits the scale and scope of research projects, as well as the ability to invest in modern equipment and facilities for research activities.

3.5 The number of large semiconductor microchip companies in Vietnam is still limited

Currently, there are only about 50 large FDI companies and enterprises investing in Vietnam in the microelectronics and semiconductor industry. Of the 40 operating companies, less than 10 are ready to recruit a large number of new students graduates every year because most companies have fewer than 100 employees. New companies entering the market, even large companies, will only recruit experienced people. Very few companies venture by recruiting new graduates when established like companies entering the market 20 years ago. But when new companies recruit people with experience from the market, old companies will also need to increase recruitment to compensate and prepare backup plans. If each new company entering the market needs to recruit 20 engineers in the first year, then 5 new companies are needed each year to create a need for 100 new engineers.

With all favorable conditions converging, in the best scenario, Vietnam will train 600 engineers each year. And each University only needs to train an average of 60 engineers/course to meet the demand. Obviously, with the current capacity of the universities, this is not a difficult problem. The main problem probably lies in the market's real absorption needs, for which each company has its own strategy. How do companies increase the recruitment rate of new graduates? How can Vietnam attract 5 new companies to open chip design offices every year or how to encourage more domestic companies?

3.6 Not many students choose to study in-depth IC design

Currently, there are only a few universities in Vietnam that provide training in the field of IC design. At Hanoi University of Science and Technology, each year the Electronics and Telecommunications Engineering major recruits 780 students, but only about 40-50 choose to study in-depth IC design. Meanwhile, universities mainly train broader or close branches. The new microchip design major appears in the training program of Hanoi University of Science and Technology, some member universities of Hanoi National University and Viet Nam National University Ho Chi Minh City, FPT University, and Posts and Telecommunications Institute of Technology. University of Technology, Ho Chi Minh City University of Science, University of Information Technology (Viet Nam National University Ho Chi Minh City) have a training scale of over 3,500 students in fields related to microchips design and semiconductors technology, in there about 200 students and 50 postgraduate students each year.

Universities in Vietnam can train 3,000 high-quality human resources annually, meeting the forecasted demand for the semiconductor and microchip industry, but face challenges in attracting students.

The Ministry of Education and Training does not have statistics on the number of human resources universities have provided to the semiconductor and chip market in recent years. However, according to some major universities, not many students choose to study this field in depth. The reason is that learning about microchips design is not as easy as software, you don't just need a computer to be able to learn like Information Technology.

In addition, social media rarely mentions the electronics and semiconductor majors in general and IC design in particular, so not many people know how great the human resource needs are in this majors. This affects pupils' career orientation.

The Director of Higher Education believes that the labor market in the field of semiconductors and microchips is just beginning to form, mainly in potential form, so it has not yet attracted students like booming majors, job opportunities are clear obvious. In addition, universities also face great challenges in improving the quality of training to meet the strict requirements of foreign enterprises [3].

4. RECOMMENDATIONS AND SOLUTIONS

To overcome the challenges in training and research in semiconductor technology and microchip design in Vietnamese universities, the following recommendations and solutions are proposed [5]:

4.1 Enhancing the training program

The training program in microchip design and semiconductor technology should be revised to include more specialized and advanced knowledge. The program should focus on both theoretical and practical training, with more emphasis on practical applications and research. The training content should be updated regularly to keep up with the latest developments and trends in the field of semiconductor technology and microchip design.

4.2 Developing the teaching staff

The teaching staff in microchip design and semiconductor technology should be trained and developed to enhance their expertise and experience. Universities should collaborate with leading institutions and enterprises in the field of semiconductor technology and microchip design to provide training and development opportunities for their teaching staff. This will help improve the quality of teaching and research in Vietnamese universities.

4.3 Improving facilities and equipment

The facilities and equipment for training and research in microchip design and semiconductor technology should be improved and modernized. Universities should invest in modern and synchronized laboratory equipment systems to enhance the practical training and research capabilities of their students and staff. This will help improve the quality of training and research in Vietnamese universities.

4.4 Strengthening research activities

Research activities in semiconductor technology and microchip design should be strengthened and enhanced. Universities should focus on applied research and the development of new technologies. They should also enhance their cooperation with enterprises and international organizations to attract funding and investment for research activities. This will help improve the visibility and impact of research activities in Vietnamese universities.

4.5 Promoting cooperation between universities and enterprises

The cooperation between universities and enterprises in training and research in semiconductor technology and microchip design should be promoted and strengthened. Universities should collaborate with leading enterprises in the field of semiconductor technology and microchip design to develop training programs, research projects, and internship opportunities for their students. This will help enhance the quality of training and research in Vietnamese universities, as well as the employability of their graduates.

5. CONCLUSIONS

Training and research in semiconductor technology and microchip design in Vietnamese universities face many challenges, but there are also many opportunities for development. By enhancing the training program, developing the teaching staff, improving facilities and equipment, strengthening research activities, and promoting cooperation between universities and enterprises, Vietnamese universities can overcome these challenges and meet the high-quality human resource demand in the field of semiconductor technology and microchip design. This will contribute to the development of the semiconductor industry in Vietnam and help the country become a major player in the global semiconductor supply chain.

6. ACKNOWLEDGEMENT

The work described in this paper was supported by Thai Nguyen University of Technology (http://www.tnut.edu.vn).

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