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Industrial-Based Learning (IBL): Promoting Excellent on Polytechnics and Vocational Higher Education

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Abstract

The industrial sector plays an important role in the national and global economy. A significant global change has shaped many industries recently: That is, industrial operation modes have shifted from local to global markets. Digital business and the implementation of extended enterprise are becoming a new playground and have become strategies for survival. Based on this, we find that more practical and business-oriented education (polytechnics and vocational higher education (PVHE), specifically) is actively participating and playing an important role in industrializing the nation. The current and future competitiveness of national industry depends on highly educated and motivated professionals, as their capabilities are critical to future industry viability. *and vocational higher education (PVHE) in* Indonesia are required to be included as major drivers with important roles in promoting excellence for national industry, leveraging their competitive advantages, and leveling up the national economics in order to cope with global challenges in the years to come[1]. In general, the practice of most PVHE in Indonesia has been carried out separately and independently from industry. It is difficult for industry to comprehend and adapt directly to the technological advances from the PVHE. Therefore, PVHE needs a new collaboration approach in order to prepare industry for innovation and to maintain its competitive advantages.

This paper will discuss a specific implementation of manufacturing education in one PVHE in Indonesia, known as Politeknik Manufaktur (POLMAN) Bandung. The discussion emphasizes the way in which POLMAN Bandung carries out manufacturing education by means of an Industrial-Based Learning (IBL) model that embraces collaboration between education and industry. Implemented in the last two decades, POLMAN Bandung's IBL model has shown its quality as a promising breakthrough for integrating a "real" industry environment with the education concept. With IBL, POLMAN Bandung has been able to establish a new definition and education paradigms within which direct involvement of all stakeholders is carried out through a number of collaborative actions linking needs of both the industrial and education systems. Moreover, IBL brings up a number of important issues in manufacturing education, such as embedding entrepreneurship and innovation within the education system, providing an education model as a means of developing qualified workforces and professionals for new job environments, and promoting an integrated approach of Tri-Dharma Perguruan Tinggi (education and training, research and technology transfers, and community services). POLMAN Bandung IBL is one of promising models in manufacturing education as it is able to address a number of emerging challenges related to industry, academia and society in general (including government); as well as to comprehend the implementation of knowledge transfer to maintain technological excellence in industry. Furthermore, POLMAN Bandung IBL also promotes and develops competency and professionalism that can be used as a strategic framework for promoting productive teaching and active learning at the PVHE in general.

Keywords: *Polytechnics and Vocational Higher Education; Industrial-Based Education; Education-Industry Collaboration; Triple-helix*

Abstrak

Industrial-Based Learning (IBL): Mempromosikan Excellent pada Politeknik dan Pendidikan Tinggi Kejuruan. Sektor industri memegang peranan penting dalam perekonomian nasional dan global. Perubahan global yang signifikan telah membentuk sebagian besar industri baru-baru ini. Modus operasi industri telah berubah dari pasar lokal ke pasar global. Bisnis digital dan implementasi perusahaan yang diperluas menjadi tempat bermain baru dan telah menjadi strategi untuk bertahan. Berdasarkan hal tersebut, terlihat bahwa politeknik dan pendidikan kejuruan (SMK) secara khusus - pendidikan yang lebih praktis dan berorientasi bisnis - harus berpartisipasi secara

aktif dan memainkan peran penting mereka dalam industrialisasi bangsa. Daya saing industri nasional saat ini dan masa depan membutuhkan profesional berpendidikan dan termotivasi karena kemampuan mereka juga penting bagi kelangsungan hidup industri di masa depan. Mengenai hal ini, politeknik dan pendidikan kejuruan (SMK) di Indonesia diharuskan untuk dibangun sebagai salah satu pendorong utama yang dapat memainkan peran penting mereka dan berpartisipasi dalam mempromosikan keunggulan industri nasional, memanfaatkan keunggulan kompetitif mereka, dan pada akhirnya meningkatkan tingkat nasional ekonomi untuk mengatasi tantangan global di tahun-tahun mendatang [1]. Secara umum, praktik PVHE paling banyak di Indonesia sampai batas tertentu telah dilakukan secara terpisah dan independen dari industri. Sulit bagi industri untuk memahami dan menyesuaikan diri secara langsung dengan kemajuan teknologi dari PVHE. Oleh karena itu, PVHE diperlukan agar memiliki pendekatan kolaborasi baru untuk mempersiapkan industri inovasi dan untuk mempertahankan keunggulan kompetitifnya. Makalah ini akan membahas implementasi khusus pembuatan pendidikan di salah satu PVHE di Indonesia yang dikenal dengan Politeknik Manufaktur (POLMAN) Bandung. Diskusi tersebut memberi penekanan pada cara di mana POLMAN Bandung melaksanakan pendidikan manufaktur dengan menggunakan model Pembelajaran Berbasis Industri (IBL) yang mencakup kolaborasi antara pendidikan dan industri. Diimplementasikan dalam dua dekade terakhir, model IBL POLMAN Bandung telah menunjukkan kualitasnya sebagai terobosan yang menjanjikan untuk mengintegrasikan lingkungan industri 'nyata' dengan konsep pendidikan. Dengan IBL, POLMAN Bandung telah mampu membangun paradigma definisi dan pendidikan baru di mana keterlibatan langsung semua pemangku kepentingan dilakukan melalui sejumlah tindakan kolaboratif yang menghubungkan kebutuhan ke sistem industri dan pendidikan. Selain itu, IBL memunculkan sejumlah isu penting dalam pembuatan pendidikan seperti menanamkan kewiraswastaan dan inovasi dalam sistem pendidikannya, memberikan model pendidikan sebagai sarana untuk mengembangkan tenaga kerja dan profesional berkualitas untuk lingkungan kerja baru, dan mempromosikan pendekatan terpadu Tri-Dharma Perguruan Tinggi (transfer pendidikan dan pelatihan, penelitian dan teknologi, dan layanan masyarakat). POLMAN Bandung IBL adalah salah satu model yang menjanjikan dalam bidang pendidikan manufaktur karena mampu menangani sejumlah tantangan yang muncul terkait dengan industri, akademisi dan masyarakat pada umumnya (termasuk pemerintah); serta untuk memahami pelaksanaan transfer pengetahuan untuk mempertahankan keunggulan teknologi di industri. Selanjutnya, POLMAN Bandung IBL juga mempromosikan dan mengembangkan kompetensi dan profesionalisme yang dapat digunakan sebagai kerangka kerja strategis untuk mempromosikan pengajaran produktif dan pembelajaran aktif di PVHE pada umumnya.

Kata Kunci: Politeknik dan Perguruan Tinggi Kejuruan; Pendidikan Berbasis Industri; Kolaborasi Pendidikan-Industri; Triplehelix

INTRODUCTION

A significant global change has shaped the industry recently. Industrial operations have transformed from local to global markets. New business models and the implementation of extended enterprises are new playgrounds and have become strategies to survive. All industries comprise an international co-operative network to provide products and support services for a world market just in time, at low prices and with quality that surpasses customer expectations. Based on this, we believe that higher education has to actively participate and play a significant role in industrializing the nation.

Higher education systems in Indonesia need to be constructed as one of major drivers to support and play an important role in promoting industrial excellence, leveraging their competitive advantages, and ultimately leveling up national economics in order to cope with global challenges in the years to come.

In directing and achieving this industrial excellence, knowledge-based education that addresses innovative human resources and educational infrastructures is crucial. Employing more practical and business-oriented education such as Polytechnic and Vocational Higher Education (PVHE) is one candidate among other higher education institutions in Indonesia that could be an important driver alongside high added-value products and services; new business models; knowledge-based engineering; and emerging technologies.

Taking all industrial activity requirements into consideration, the following elements will shape the future standpoint of PVHE excellence : Knowledge and skilled workforce, Attractive education program (to the young), Multidisciplinary education, Setting a priority on pioneering spirit, Integrated research, innovation, and education.

All PVHE should respond to their significant roles and follow a new approach in order to prepare industries for future generation and growth. Therefore, the PVHE should: Develop and renew their strategic objectives, Highlight new challenges, Formulate unique educational paradigms, Develop integrated plans and actions.

In order to cope with these challenges, new strategic developments for future PVHE require: *Synergy between academics and industry*. Facilitating integrated academic activities (education and training, research and development, and community/industrial services) that can impact industrial competitiveness and technological development significantly, *Developing competencies required for the next generation of human resources for industry*. The PVHE program should fulfill the new requirements of knowledge-based industry, promote innovation and entrepreneurship, and focus on teamwork, leadership, and integrity, as well as global awareness and a multi-cultural spirit.

Regarding future industrial challenges in business operation, all PVHE in Indonesia are required to identify a suitable education initiative/model in relation to their excellence with respect to the recent educational system, and an appropriate curriculum for the specific requirements of the local industries. The underlying idea for this is that the development of the curriculum or academic program should be based on a global definition and understanding of the industry requirements for education and training.

This paper tries to answer the above questions by offering an initiative/model, called Industrial-Based Education (IBL) which has been implemented at one polytechnic institution, Politeknik Manufaktur Negeri (POLMAN) Bandung. The explanation of the initiative will be focused on the way in which IBL integrates between the industrial environment and education systems in order to provide knowledge transfer to maintain technological excellence in industry and the development of qualified workforces for industry through academic activities.

Before deliberating about IBL, this paper will first highlight the global perspective in order to comprehend today's market demands on human resources with regard to the issue of industry excellence. Furthermore, the paper will then draw attention to some challenges and opportunities in global trends in the education system. Toward the end, some constraints and recommendations concerning the implementation of IBL will be addressed.

Global Perspective on Human Resources

Human resources are the strategic assets that education systems should prepare to continuously adapt and transform knowledge into a competitive tool by producing high added-value products for industry. In preparing the next generation of human resources and fulfilling the requirements of global human resources, the following aspects should be considered carefully: *Today's dilemmas*: globalization, knowledge management, time & cost reduction, global supply chain, multi-resources, resources utilization, human resource development based on performance, human resource management, implementation of strategic planning, process measurement & analysis, corporate culture, outsourcing, learning organization, *Systematic and integrated process*: Parallel/Simultaneous, *Utilization of information and generic systems*, *Mobilization of innovative human resources*, *Characterized by knowledge and information-based*

We must consider these aspects due to new environment in the labor market, which has experienced some significant changes: *Organizational*: integration, *Paradigm*: flexible, lean, and team oriented, *Workplaces*: knowledge- and response-based, *Workforces*: solving problems, multi-cultural, proactive, contribution, and total participation, *Qualification requirements*: interdisciplinary abilities/attitudes, *Principles of future working organizations*: decentralized decisions, knowledge collaboration, interaction, competency based.

These new environments will have a significant impact on the academic world, and particularly on PVHE in Indonesia, which brings them to a choice: do they trail behind, or do they shape a new role and actively participate in the change processes of technology and economic development? As one way of shaping its new role, the PVHE should establish a collaboration with industry, professional associations, and government, particularly as related to curriculum development and education/training process evaluations.

As a benefit of this collaboration, it is expected that PVHE will be able to provide qualified graduates and professionals who are not only ready to work but are also competent in solving industrial problems, have good career development, and be able to improve social status and incentives. For industries, it becomes easier to recruit qualified professionals and reduce the cost for personal recruitment. Thus, the government as a regulator will get the support in assuring a national, more competitive qualification standard, reducing the need for training centers, and assuring national social and economic stability.

Global Education: Challenges and Opportunities

In the coming decades, we can foresee that the interaction of key factors related to globalization, emerging technologies, market demands, public values, fiscal measures, and regulation and societal changes will contribute to shaping the future of global industry. Within this

context, key challenges must therefore be addressed by the education initiative and its stakeholders.

New global challenges and opportunities have emerged for the development of PVHE in Indonesia. One of the most demanding changes is that the national PVHE system must align with global educational systems, particularly as related to the following: *Internationalization and Globalization*. A key challenge to leveling up human resources and more international and global knowledge, as well as to overcoming fragmentation and creating multidisciplines and multi-cultural synergies., *Entrepreneurship and Innovation*. The major driving forces for continuously providing the customer with added value, which is crucial to keeping and maintaining industry competitiveness. Embedding entrepreneurship and innovative spirit in the education program is a major challenge for the future, *Education Attractiveness in Society*. A key challenge to developing innovative programs that promote the attractiveness of industry to young talents, *Value Creation Status and Job Positions*. A major challenge to provide an excellent higher education that can educate and train high-level personnel for new industrial jobs, *Future Industrial Curricula*. To consider and focus on: industrial strategy; capability of human resources working in teams, broad knowledge of modern and advanced industrial practices (i.e., managing projects and other people).

IBL Initiative of POLMAN Bandung

For Indonesia, with its unique geography and leading population size, higher education requires a concept and strategy for its national development which concentrate on both industrial sectors and services. In most cases, higher education institutions in Indonesia, including PVHE, are still acting separately from the industry. The output of their educational programs often fails to meet the needs of industries due to educational curricula that have not kept pace with the growing complexity of industry or economy, or with the rapid advance of new technologies. The outcomes of academic research and development are typically presented within the scientific community, through technical papers in scientific journals, presentations in conferences, workshops etc., and are not directly accessible to the industrial community. In this way, it is difficult for industry to comprehend and adapt directly to technological advances.

Due to these challenges, POLMAN Bandung - PVHE institution has a particular mission to support and provide human resources for the manufacturing industry. It has positioned itself as part of the industrial sets, from which educational program development is derived to meet industry's expectations and fulfill future industry competency level requirements. Since its establishment in 1975, when it was known as Politeknik Mekanik Swiss (PMS)–ITB, POLMAN Bandung has promoted education initiatives to provide motivated and highly skilled manufacturing technicians as well as technologists who are ready to work and solve industrial problems in technological implementations and in the areas of precision mechanics and tooling.

Characterizing its education through distinctive programs leading to practical business-oriented professional careers, POLMAN Bandung has continuingly challenged and strengthened itself in the last two decades by implementing the Industrial-Based Education (IBL) education initiative, which promotes and develops competency and professionalism. This IBL has become a strategic framework for promoting productive teaching and active learning, generally in polytechnic education, particularly at POLMAN Bandung. The basic idea of IBL involves combining theory, lab practices, and real industrial practices by inserting a real industrial order/project into students' practice programs and substituting structured exercises. In dealing with industry and market needs, POLMAN Bandung considers and follows business rules and practices, without ignoring the main objectives and goals of the education/training, as well as student competency set-ups in the curricula.

IBL Concept

The IBL concept is a unique paradigm in manufacturing education and training. The IBL main objective has progressed to integrating the manufacturing enterprise environment and practices with education and training activities. To comprehend how POLMAN's IBL is implemented, Figure 1 illustrates how the education and training activities employ teaching/training schemes for transferring, digesting, and validating knowledge, as well as for professional/skill development through industrial practice and business-like working methods.

Figure 1. POLMAN Bandung IBL adapted form Gilman J W, Jackson C L, Morgan A B, et al

These methods address knowledge transfer schemes to keep education and training at the technological forefront by supporting the continuous comprehension of the technical essence and the business potential of new technological applications. As a result of implementing them within a real industrial environment, the methods concurrently provide feedback to education and training (academia) in term of gaining experience and skills, as well as technological applications and solutions.

IBL Implementation

As mentioned previously, the key implementation of the IBL focuses on integrating the education system and manufacturing enterprise practices and businesses concurrently, which involves combining teaching-learning activities and manufacturing processes. This can be done on the campus and/or directly in the industry. The following describes two approaches of the IBL deployed at POLMAN Bandung that are utilized to deliver qualified graduates who comply with the quality required by the industries.

Teaching Industry: POLMAN Bandung has transformed itself from a traditional/pure education institution into a teaching industry. Industries are invited to provide real industrial cases (orders/projects). Supported by its educational character and a very strong practical and production-based education, all of the structured practical exercises are transformed into a flexible exercise scheme according to job planning and required competencies. After students have acquired basic manufacturing technological skills, the orders/projects of simple industry products are introduced to the education and training process. In other words, students are engaged and involved in directly managing a production/project activity that fits in the structured practical exercises. In the circumstance where the complexity and delivery time of the order/project is more and more difficult to manage at the same time as the quality of the educational program must be maintained, the involvement of the lecturers, instructors and technicians is crucial. The following list shows four categories of the industrial orders/projects with respect to the jobs' complexity and delivery time, as well as the roles of the lecturers, instructors, technicians and students (the executors) in production activities: *Less Complexity–Less Tight Delivery Time:* Since the job complexity is still less equal to student competency, and there is a plenty of time to deliver the job, the students are assigned to fully execute the job under moderate supervision by the lecturers/instructors. *Less Complexity–Tight Delivery Time:* Similar to previous category, close supervision by the teacher/instructor is required due to the tight delivery time. *High Complexity–Less Tight Delivery Time:* High-complexity jobs require the lecturers/instructors to be involved by partly executing the job first in order to lower the job complexity so that students have enough competencies to partly execute the job. *High Complexity–Tight Delivery Time:* This is an extreme situation where it is not recommended that lecturers/instructors or students execute the jobs. Therefore, the technicians (professionals) are fully responsible for executing the jobs.

Industrial Internship (On the Job Training): To understand more comprehensively how a real industry is run and to understand its real environment, students are placed in the selected industries for two semesters (effectively 10 months) and mainly engaged with production and/or project activities as team member according to their field of specialty. In this placement, students are expected to not only gain real industrial experience, but also have opportunities to implement their competencies and learn the professional value of working in industries. To assure quality, a set of monitoring and evaluation programs is designed, including a selection of the industries; scope of work; supervision and monitoring; and evaluation mechanism. In term of industry selection, POLMAN Bandung assigns an ad-hoc team to analyze and evaluate the industry's prospects. The team ensures that the industries are in the field of manufacturing and are appropriate for students from available study programs at POLMAN Bandung. Thus, the team also ensures that appointed industries have related programs that the students will execute during their internship programs. The internship program is then assessed and should be agreed upon within the scope of work designed by POLMAN Bandung. If both POLMAN Bandung and its industrial partner agree upon the requirements, the students are then placed and work as employees in the selected industry for two consecutive semesters (effectively 10 months). During their internship program, two supervisors from both POLMAN Bandung and the industry are assigned to supervise, monitor, and evaluate the student's work and progress. In this supervision, monitoring, and evaluation, a mechanism is designed such that: a) the student reports their works and progress to both supervisors by writing a weekly journal, and b) the supervisors monitor and evaluate the student's work and progress at least twice in each semester. Supervisors from POLMAN Bandung visit the industry to monitor and evaluate by meeting directly with their counterparts (industry supervisors) and the students.

IBL Consequences

To support the implementation of the academic program in the IBL scheme, POLMAN Bandung undertakes two important steps: Restructuring Organization: As a higher education institution, the structure and function of several sub-organizations in POLMAN Bandung are reformed. The most important constraints for restructuring the organization are**:** Government regulation, Flexibility to accommodate manufacturing and business activities, Empowering all resources, Efficiency and effectiveness, and Productivity

POLMAN's new organizational structure is then defined as three main functional organizations: Centers: The main function of the centers or pullers is to manage activities in product development and industrial services. Centers define specifications and programs which are executed by divisions/departments. The centers are matrix sub-organizations which work with commissions and project teams staffed by professionals from divisions/departments. There are three centers:

Center for Education to do Academic Planning, Control and Development: Formulating curricula, syllabi, education and training programs; Academic administration; and Academic Development

Center for Engineering and System Development: Product Engineering and Design; and Manufacturing System and Process Development

Center for Industrial Services: Public relations; Marketing (market analysis and market strategy); Customer service & sales; Planning and control of the internal program execution Centers as a Puller

Departments/Divisions: The core parts of the organization that are responsible for carrying out education and training, design and manufacturing process, and prototyping. The Departments/Divisions have adequate facilities and are supported by qualified personnel/professionals.

Units: A supporting organization that renders service and support in all activities carried out by centers or departments/divisions. The Unit can also be part of a division or center.

Setting up Quality Assurance: The various activities in the matrix organization require a management system to assure that all works/jobs are completed according to standard, so that the quality of the outputs (product and service) conforms to the requirements. Therefore, POLMAN Bandung has been certified for a quality management system that complies with the requirements of the ISO 9001:2008 in Curriculum Design and Provision of Higher Education Services, as well as in Design and Manufacture of Metal Castings, Precision Tools, and Production Machines and Control Systems. The ISO 9001:2008 for quality management systems requires that all activities completed for a designated area are conforming to defined procedures, recorded, identified, and traceable. The system manages what, when, where, why, and how things are done and who is responsible for each activity. By implementing this quality management system, POLMAN Bandung ensures that the output conforms to standard requirements, including :

Human Resources: To back up the defined programs, the need for personnel with high professional competence and skills or special qualifications is inevitable. POLMAN Bandung has set the Diploma 3 (D3) Polytechnic formal education as a minimum qualification for all personnel involved in education, production and engineering programs. In spite of that, they are only involved in specific technical execution in engineering, design and manufacturing. To be qualified for supporting IBL, 40–50% of staff should possess one or two qualification levels higher than D3. Internal training becomes mandatory. All employees must take Quality Awareness Internal Training in addition to other specific technical internal training. All development activities are done metrically by committee, project team or task force. With this system, POLMAN Bandung is implementing Total Quality Management.

Infrastructure and Facility: The POLMAN Bandung academic program can only be run optimally with the support of adequate facility and infrastructure. The minimum competency could be reached in a “one-to-one” condition, which means one student to one machine facility. The facilities must be set to go with industrial scales that are regularly calibrated, and each of the nonconformities must be recorded in a quality documentation system and corrective action must be taken. Rapid development of advanced manufacturing technology forces POLMAN Bandung to continually update its education facilities. Some conventional facilities have been replaced by automatic and programmable ones, or even by intelligent technology.

Constraints and Recommendations

In order to successfully address the challenges of implementing IBL and achieving the new objectives of PVHE in Indonesia, a number of integrated actions linking people and societal needs to both the industrial and education systems are recommended. A systematic approach requires that such actions be identified by multiple stakeholders. In order for these actions to be effective, varying

educational and business cultures and regulatory frameworks across stakeholders should be respected. As recommendations, a number of actions that could be considered important and applicable include:

Specific government policies are required in order to facilitate an educational institution to set up a company-like infrastructure so as to apply the academic output and research results and then gain the benefits and profits; The development of centers of excellence and hubs/networks for knowledge and technology to efficiently design a structure of excellence in education and research; Upgrading human resources and knowledge/information to become more international to increase the mobility of human resources, either through student exchange schemes or in industry/academic institution partnerships; Improvement in collaboration among human resources in the knowledge-based chain; Strengthening synergies between academia and industry through intensifying collaboration needs toward, for example, the transfer and dissemination of knowledge, research and development (innovation), the establishment of joint degree programs, industrial training, industrial real-life driven courses, and manufacturing departments and/or universities driven by industry; The investigation of required focus and structure for future PVHE curricula, and the integration of industrial qualifications in national and international engineering technology curricula; Reorganization of the PVHE program for the highest potential impact on competitiveness; Synergies between major stakeholders (triple-helix) for improving the innovation in industrial environments, particularly in identifying strategic directions of innovation and supporting the undertaking of respective business risks; The development of intellectual mechanisms for which the knowledge and expertise acquired and developed by academia could flow directly to industry; Placement of technology transfer to industrial processes so that proven technology developments can be implemented and integrated into processes; Promoting international synergies for defining future strategies on PVHE and activities in order to improve industrial education and training; and Supporting new models and paradigms in PVHE (i.e., the POLMAN Bandung IBL).

CONCLUSION

As industrial excellence becomes more important mission of every nation, the importance of PVHE is significant, particularly in Indonesia, in producing highly educated and motivated workforces. PVHE initiatives should fulfill the new requirement for knowledge-based industry which puts forward skills required for next-generation human resources for the industry.

Accordingly, PVHE institutions in Indonesia have to challenge themselves to set up unique concepts/models for education and training programs in order to provide workforces with new competencies and qualifications that suit the new industry generation. Collaboration between academia and industry is one important strategy for this direction. Implementing real-life industrial practices within education activities is considered a catalyst in this collaboration. With a growing emphasis on lifelong learning, it is essential for industry and educational institutions to form strategic alliances to ensure human resource development.

The POLMAN Bandung experience indicates that POLMAN's IBL will become a breakthrough for the future perspective of PVHE excellence in Indonesia. The industry integrated education through IBL is an integration of education and training, engineering and design, and community and industrial services (production activities) in a business environment. With this IBL, POLMAN Bandung proves its best practice to fulfill the requirements of industry excellence, particularly in providing a suitable education system/model with respect to the global educational system/model, and appropriate curricula for the specific requirements of local manufacturing industries.

Finally, by running an education program with the IBL concept, POLMAN Bandung has proven that providing qualified manufacturing professionals for industry is not necessarily a high cost center. Moreover, the education program can also become the responsibility of and be implemented by industry in general to accelerate a country's competitiveness.

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