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TECHNOPARKS AS CATALYST FOR SUSTAINABLE FUTURE INNOVATIVE ECOSYSTEM IN VOCATIONAL SCHOOLS

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Abstract

Vocational schools are crucial in creating a skilled and adaptable workforce in an era of rapid technological development and a changing industrial landscape. This study aimed to describe integrating technology park activities to promote sustainability in vocational schools, focusing on the Center of Excellence (CoE) model. This study used mixed methods. The study was conducted at 22 High Vocational Schools (HVS) in Aceh Province, and the subjects of the study were 22 principals, 22 teaching factory coordinators and 110 students. Data collection methods were qualitative and quantitative data analysis using observation, interviews and recording followed by data reduction, data display and conclusions. The study was expected to provide a strategic framework for the sustainable development of vocational schools within the technology park paradigm. Students differentiated skills and characters and HVS collaboration through Techno parks by identifying the curriculum enhancement. The results showed a significant shift in vocational school curricula to more dynamic and technology-based curricula, a positive effect on hard skills (practical skills, technical influence) and soft skills (independence, teamwork, critical thinking) of students and active collaboration done through techno park activities.

Keywords: *Technopark; Center of Excellence; Future Innovative Ecosystem; Vocational Schools.*

A. Introduction

In the contemporary landscape of technological progress, vocational education stands as a linchpin for cultivating a skilled workforce adaptable to the ever-evolving demands of industries (Murniati et al., 2022). As technological disruptions reshape traditional employment paradigms (Helbling& Sacchi, 2014), the convergence of techno-park strategies with vocational education emerges as a promising avenue for preparing students with traditional and cutting-edge skills.

Technology parks are known for nurturing innovation ecosystems primarily associated with higher and vocational education institutions (Ilyas et al., 2012). In recent years, emphasis has been placed on integrating Technopark initiatives into vocational training as part of a strategic approach to meet the changing demands of the Indonesian labour market (Tolinggi, 2018). Techno parks serve as dynamic ecosystems that connect educational institutions and industry, encourage innovation, and facilitate technology transfer and practical skills development (Nurmalasari& Swaramarinda, 2018). In the context of professional training, the introduction of technoparks brought essential changes in the adaptation of training programs to the needs of the industry (Lubis et al., 2023; Abdillah et al., 2022). These initiatives often include state-of-the-art facilities, industrial projects and company partnerships to provide students with hands-on experience.

Recognizing the potential of technoparks to improve vocational training, the Indonesian government launched a program to establish and support such centres nationwide. This joint effort seeks to equip career students with traditional skills and advanced technical expertise to prepare them better to meet the challenges of a technology-driven workforce (Murniati, 2016; Nuranifah et al., 2022).

Despite promising progress, integrating technology parks into vocational education in Indonesia is challenging. One of the key obstacles is the massive investment in infrastructure, technology and teacher training required creating and sustaining these innovation hubs. Due to limited financial resources, it can be challenging to establish a fully equipped technopark, especially in regions with limited economic resources.

In addition, coordination between academic institutions, industry and government agencies requires careful planning to ensure ongoing collaboration and effective knowledge transfer (Ananda & Mukhadis, 2016). Another challenge is that traditional education systems may need help to keep up with the dynamic nature of emerging technologies, requiring an adaptable curriculum that can quickly respond to the changing needs of the industry. Addressing these barriers requires a comprehensive approach that includes strategic funding, strong public-private partnerships, and continued efforts to modernize career education systems in line with the goals of the technology parks initiative (Arifin, 2009; Lailatussaadah et al., 2023).

However, technoparks in vocational schools still need to be sufficiently explored. Technopark appears to be a comprehensive solution for creating and improving pedagogical excellence (PE) centres in vocational education systems (Khoiron, 2016). By design, technology parks are dynamic ecosystems that integrate innovation, industrial collaboration and cutting-edge technology. Within the Technopark framework, a Center of Excellence becomes more than an isolated initiative; it becomes a dynamic nucleus embedded within an ecosystem designed to foster collaboration, research, and continuous development (Nurlaela et al., 2022). This is a dynamic basis for continuous cooperation, research and development. The shared infrastructure, industry links and state-of-the-art facilities offered by Techno Parks give Centers of Excellence the support they need to thrive. This comprehensive approach ensures that professional education is flexible and responsive to ever-changing business needs, enabling students to acquire traditional skills and advanced practice. As the Technopark model gains traction, it will be an innovative solution that will take Centers of Excellence to new levels and redefine the professional learning environment, seamlessly linking academic excellence with real-world applications (Chukwu et al., 2019; Usman et al., 2021).

Technopark is an integrator that connects fellow Vocational Schools implementing teaching factories, facilitating the process of creating and supporting innovation-based industries through business incubation and spin-off processes, as well as providing other value-added services through

the provision of quality space and facilities to support it (Kholis et al., 2020; Muhith et al., 2023). The teaching factory learning concept held at this technopark is expected to produce practical products and services with economic value so that the market can widely accept them.

The urgent need to address the growing skills gap in the workforce underscores the urgency of this research. As industries increasingly adopt advanced technology, the traditional skills taught in trade schools may need to be improved (Amaly et al., 2023). The timely integration of science and technology park initiatives provides a strategic response to this urgency, enabling students to acquire diverse skills, including traditional vocational and modern technological skills (Ferdian & Suyuthie, 2022).

The Center of Excellence (CoE) model is a focal point for excellence in specific domains within the Technopark framework. This research recognizes the CoE as a catalyst for innovation and skill development within vocational education (Siswandi & Sukoco, 2016). By concentrating efforts and resources, CoEs can become transformative hubs, nurturing talent that meets the highest industry standards. Understanding the nuances of implementing and optimizing the CoE model in vocational schools is central to unlocking its full potential.

Based on several previous studies related to the development of learning in vocational schools only state that technoparks are a new step towards developing teaching factories in the future (Sudana& Supraptono, 2017). However, only a few discuss the application of technoparks in vocational schools. The study conducted by Sudiyantno and Wulandari reported that the evaluations of Science Technopark on the youth in Solo Technopark had contributed toward good learning level contribution (knowledge and essential skill) and good behaviour (attitude and primary skills) changes of the youth and alums high skill at workplace (Sudiyatno & Wulandari, 2020).

Furthermore, the previous study conducted by Kristanto et al. (2023) suggested that the implementation of the teaching factory is progressing well, and the school's teaching factory is now a state-of-the-art technology park, supporting the learning factories of the school's programs. In addition, the learning factory contributes significantly to hands-on

learning, production processes and school quality at SMK Muhammadiyah 1 Sukoharjo (Kristanto et al., 2023).

In conclusion, this research explores the dynamic interplay between Technopark initiatives and vocational education and charts a course for future implications. By uncovering innovative strategies and best practices, the study aspires to pave the way for sustainable vocational school development, ensuring that vocational students are well-equipped to navigate the complexities of modern industries. The findings of this research hold the potential to influence policy decisions, reshape educational practices, and contribute to a paradigm shift in how vocational education adapts to the demands of the future workforce.

As for the research questions in this study, among others: How does integrating Technopark initiatives, specifically the Center of Excellence (CoE) model, impact vocational schools' curriculum design and content?; What are the implications of technoparks implementation toward developing students' skills and characters? What are the collaboration models between vocational schools through technopark and other stakeholders, particularly in fostering professional partnerships, technological fluency, students' skills upgrade, ad vocation, and partnership programs?

B. Method

This study used a mixed methods approach involving qualitative and quantitative data. A descriptive online study design using quotation sampling was used. The study involved 22 secondary vocational schools in Aceh province with 154 respondents, including 22 school principals, 22 teaching factory coordinators, and 110 students.

First, to demonstrate the validity and reliability of the study, the research instrument was pilot-tested with 30 students and 10 managers and coordinators of teaching factories outside the study. Validity and reliability tests used Pearson's validity and Cronbach's Alpha reliability. This study used the product-moment correlation formula to test the instrument's validity.

$$rxy = \frac{N\Sigma XY-(\Sigma X)(\Sigma Y)}{\sqrt{(N\Sigma X^2-(\Sigma X)^2(N\Sigma Y^2-(Y)^2)}}$$

If the value of each question exceeds 0.6 and r, the instrument is considered valid. Xy> r. table. Based on the validity and reliability testing results of the 30 items, 10 were found invalid and excluded from the questionnaire for principals and training factory coordinators.

The researchers then distributed the questionnaire to each principal who was the target of the study. Each principal then passes these instruments on to the teaching factory coordinator and students. The learning factory coordinator distributed the questionnaire to the students via class group (WhatsApp) and email. Questionnaire items were set up using the Google Forms application.

Data analysis was conducted after collecting all the information through interview recordings with respondents and data triangulation. In this study, the researchers used a Likert scale to measure the participants' attitudes and opinions regarding students' perceptions of skill and character improvement during technology park activities.

Response rates for each statement item are as follows: strongly agree (5), agree (4), somewhat disagree (3), disagree (2), and strongly disagree (1). In addition, a Guttman scale was used to assess collaboration between business schools and other stakeholders, and yes/no question opportunities were provided.

Interpret intervals using percentages using the formula n/N X100%. The percentage ranges are interpreted as 0%–20% (fail), 21%–40% (weak), 41%–60% (adequate), 61%–80% (strong), and 81%–100% (solid). Mean value interpretation: 4.51-5 (very high), 3.51-4.50 (high), 2.51-3.50 (medium), 1.51-2.50 (low) and 1.00 -1.50 (lowest).

C. Result and Discussion

1. Result

The study's results reveal a multifaceted impact of integrating Technopark initiatives, notably the Center of Excellence (CoE) model, into

vocational schools, including curriculum enhancement, students' differentiated skills and characters, and schools' collaboration model.

a. Curriculum Enhancement

Integrating technology park initiatives has significantly influenced the development and content of vocational school curricula. The results show a significant shift in curricula towards more dynamic and technology-based courses that ensure students acquire a wide range of skills that match traditional vocational skills and emerging industry needs. The Council of Europe model acted as a catalyst for this change, providing a framework to bridge the gap between traditional vocational education and the needs of modern industry.

Here are responses to questionnaire questions about curriculum enhancement through technopark as a part of the teaching factory in the Center of Excellence within the context of the National Emancipation Curriculum (Merdeka Belajar).

1) The integration of technopark initiatives influenced the curriculum

The following are fragments of conversations from principals, teaching factory coordinators, and students about curriculum enhancement.

One of the school principals stated*:*

"The integration of Technopark initiatives has significantly changed our curriculum as part of 'Merdeka Belajar'. We underwent a complete overhaul in the Center of Excellence training factory, focusing on integrating real-world industrial practice (SMK 1 Meulaboh Principal)".

In addition, other school principals also argued.

"With the existence of the technopark, there are many developments that we feel such as cutting-edge technologies, and collaborative projects. This shift has been instrumental in aligning our curriculum with the demands of the modern workforce (Principal of SMK 1 Tapak Tuan)".

Furthermore, the teaching factory coordinator of SMK 3 Takengon said.

"A big challenge is to ensure that all school members have the skills and knowledge needed to teach the new curriculum. We are addressing this by

providing comprehensive training programs and establishing support systems for ongoing training. In addition, allocating resources to technology infrastructure requires strategic planning to meet the needs of an advanced curriculum".

Moreover, the principal of SMK Kuala Simpang said.

"Our hopes are high. We expect that these curriculum changes will not only prepare students for today's technology landscape, but also instill in them a future-oriented mindset. We want our students to become not just consumers of technology, but also innovators who are ready to embrace the challenges and opportunities presented by an ever-changing technology-driven world. The long-term effect should be a generation of graduates who are not only academically strong, but also technologically savvy and well-prepared for the demands of the workforce".

2) *The inclusion of technopark initiatives contributed to the development of a diversified skill set among students*

The teaching factory coordinator of SMKN 1 Karang Batu stated that.

"The inclusion of Technopark initiatives has played a pivotal role in nurturing a diversified skill set among students within the teaching factory. Through hands-on experiences, exposure to industry practices, and engagement with technopark resources, students are not only honing traditional vocational skills but also gaining proficiency in emerging technologies (SMKN 1 Karang Batu)".

In addition, the principal of SMKN 2 Sinabang argued that:

"This diversified skill set ensures that our graduates are well-equipped to meet the dynamic challenges of the contemporary job market (teaching factory coordinator of SMKN 2 Sinabang).

3) *The Technopark model enhanced the collaboration between the teaching factory in the Center of Excellence and industries.*

The coordinator of the teaching factory at SMK Al Murbakeya stated.

"The Technopark model has created a robust platform for collaboration between the teaching factory and industries. Industry partnerships have flourished through collaborative projects, internships, and mentorship programs".

This has ensured a constant flow of real-world insights into our curriculum, making it more industry-relevant (Principal of SMKN 3 Lhokseumawe).

> *"The Technopark network serves as a bridge, connecting students with professionals and providing a tangible link between classroom learning and industry requirements (Teaching factory coordinator of SMK Bandar Dua)".*

In addition, the teaching factory coordinator of SMKN Meukek stated.

> *"Partnering with Techno Park is a game changer for our teachers. They are committed to continuous professional development and participate in seminars and training courses led by Technology Park experts. This collaboration instils a spirit of innovation in our educators, allowing them to incorporate the latest technological advances into their teaching methods".*

4) *Technopark-driven changes in the curriculum impact students' learning experience.*

Most of the students have responded positively to the Technopark-driven changes in the curriculum. The practical exposure and hands-on projects facilitated by Technopark initiatives have enhanced their enthusiasm and motivation. The learning experience has become more engaging, and students report a better understanding of theoretical concepts through real-world applications. These changes have contributed to a more dynamic and enriching educational journey for the students.

In addition, the principal of SMK 1, Labuhan Haji said.

> *"The impact is far-reaching. Students are not just consumers of technology; Now they are active participants and creators. The curriculum emphasizes hands-on learning as students participate in projects that include coding, robotics, and other technology-based activities. This transformation makes learning more engaging, relevant and reflective of real-world applications (SMK 1 Labuhan Haji)".*

The principal of SMK 2 Takengon also said that.

> *"The curriculum now includes modules on emerging technologies, coding languages, and practical applications of technology in various fields. We have also introduced interdisciplinary projects integrating technology*

across subjects, fostering a holistic understanding of its role in different domains (SMK 2 Takengon)".

Additionally, the curriculum has become more flexible, allowing us to adapt quickly to the ever-evolving tech landscape (SMK 1 Takengon).

5) *The challenge encountered in implementing the Technopark-driven curriculum changes for technology integration*

While integrating Technopark initiatives has benefited immensely, specific challenges have been encountered. These include additional resources for advanced technologies, ongoing faculty training to keep pace with industry trends, and ensuring seamless coordination between the teaching factory and Technopark activities. Addressing these challenges is essential to sustaining the effectiveness of the curriculum changes and ensuring continuous improvement.

In addition, the coordinator of the teaching factory at SMKN PP Saree stated that.

"*The Main Horticultural Seed Center located in this area acts as a place for research and development of horticultural seeds in Aceh Province. Meanwhile, the Agricultural Training Center is a centre for developing innovation and transformation of agricultural technology, such as various installations resulting from organic fertilizer and biogas processing innovations, hydroponic installations, aquaponics farmer's Argo Market, and the development of organic agriculture*".

Integrating Technopark initiatives has been a transformative force in shaping our curriculum towards technology. It is not just about adopting the latest gadgets or software; it is a fundamental shift in our approach to education. "*We have moved from a conventional curriculum to one that is dynamic, industry-aligned, and deeply rooted in technological advancements*" (Teaching factory coordinator of SMK 3 Meulaboh).

Furthermore, the principal of SMKN 1 Mesjid Raya stated that the availability of these facilities supports the development of the technology integration in this school. The creative products developed through the establishment of 'Smiketechnopark' are creative metal crafts and jewellery, textiles, and woodcraft products.

Moreover, SMKN 2Takengon also developed the Department of Engineering Technology with sub-departments in Light Vehicle Automotive Engineering, Electrical Power Installation Engineering, Audio-Video Engineering, Mechanical Engineering, and Construction and Property Business to support teaching factories at school.

b. Students' Diversified Skills and Character Development

The following table describes students' perceptions of the influence of the technopark in improving their diversified skills and character.

Table 1. Students' diversified skills and characters development during teaching factory through technopark

Variables	N	Mean	Percent (%)	Std. Deviation
Knowledge improvement (soft skill)	110	4.32	86,4	.716
Industrial culture (life skills)	110	4.55	91	.853
Practical skill (hard skill)	110	4.55	90,8	.852
Independence	110	4.32	86,4	.716
Teamwork	110	4.33	86,6	.718
Critical thinking	110	4.32	86,4	.716
Entrepreneur spirit	110	3.57	71,4	.962
Creative	110	4.32	86,4	.716
Global Diversity	110	4.32	86,4	.716
Technology influence (digital skills)	110	4.00	80	.929
Valid N (listwise)	110			

The table above shows information about student's perceptions of the influence of technoparks on student competencies and characters, where the top five ranks were industrial culture (91%), practical skills (90.8%), teamwork (86.6%), knowledge improvement, independence, critical thinking, creativity, and global diversity (86.4%).

c. Challenges and Opportunities in Collaboration

The study identifies the main challenges and opportunities for cooperation between business schools using technology parks. Challenges include bridging institutional differences, aligning course objectives with industry requirements, and ensuring equitable access to technology-enhanced

learning resources. On the positive side, successful industry partnerships, liquid technology programs and entrepreneurial initiatives in the research park ecosystem provide valuable opportunities for business students to gain hands-on experience and improve their employability. Table 5 below describes the cooperation of vocational schools through technopark.

Table 2. Vocational Schools' Collaboration

Variables	N	Mean	Percent (%)	Std. Deviation
Industrial work practice	22	.32	31,8	.477
Student assessment	22	.64	63,6	.492
Industry visits/Prakerin	22	.36	36,4	.492
Workshop	22	.55	54,5	.510
Recruitment/placement of graduates	22	.45	45,5	.510
Guest teacher	22	.55	77,3	.510
Job training	22	.77	54,5	.429
Curriculum synchronization	22	.77	77,3	.429
Student licensing	22	.55	54,5	.510
Curriculum validation	22	.77	77,3	.429
Production unit	22	.59	59,1	.503
Fulfilment of facilities and infrastructure	22	.77	77,3	.429
Seminar	22	.50	50,0	.512
Sharing committee	22	.59	59,1	.503
Teacher-internship	22	.68	68,2	.477
CSR (Corporate Social Responsibility)	22	.68	68,2	.477
Scholarships from industry	22	.59	59,1	.503
Valid N (listwise)	22			

Based on the analysis of the questionnaires distributed to each principal, the data shown in the table above shows that the most collaboration between vocational schools and various stakeholders includes guest teachers, curriculum synchronization, curriculum validation, and fulfilment of facilities and infrastructure, each by 77.3%. The rest is 68.2% collaboration in teacher-internship and CSR, 63.6% student assessment, and 59.1% scholarships from industry, sharing committees, and production units.

2. Discussion

The results provide valuable insight into the multifaceted impact of integrating technology park initiatives, notably the Center of Excellence (CoE) model, into business schools. Discussions will be based on identified topics: curriculum improvement, student diversity skills and character development, and challenges and opportunities for collaboration.

First, research results show a significant shift in vocational school curricula to more dynamic and technology-based curricula (Kholis et al., 2020). The critical role in this transformation was integrating technology park activities, notably the Centre of Excellence model. Responses from school leaders emphasized comprehensive reforms that emphasize real-world industrial practices and advanced technologies (Hidayat, 2016). It meets the needs of today's workforce. Curriculum reforms promoted by the Technology Park events aim to adapt professional education to the needs of the modern workforce (Shaidullina et al., 2015). Principals emphasize preparing students for the current technological landscape and instilling a mindset to adapt to future challenges (Mavrikios et al., 2018; Psacharopoulos, 2006; Tabrani ZA et al., 2023).

Curriculum reforms aim to produce academically strong and technically qualified graduates (Usman et al., 2020). The results highlight the challenges of implementing technology-park-driven curriculum changes. These challenges include advanced technologies that require additional resources, ongoing teacher training, and seamless coordination between factory education and technology park activities (Klotz et al., 2014; Usman et al., 2020b). The response from the teaching factory coordinator highlights the importance of addressing these challenges to sustain the effectiveness of the curriculum changes.

Second, the study included students' perceptions of the impact of science and technology parks on their abilities and personality. The top-level domains are industry culture, practical skills, teamwork, knowledge enhancement, independence, critical thinking, creativity, and global diversity (Fakhri & Widjanarko, 2018; Kärner & Warwas, 2015; Zurqoni et

al., 2018). This reflects a positive effect on hard skills (practical skills, technical influence) and soft skills (independence, teamwork, critical thinking) (Fjellström, 2014; Maulida et al., 2017; Pearce, 2015; Quesada-Pallarès et al., 2019; Winser & Klotz, 2013).

Third, the study identifies collaboration challenges, including overcoming institutional differences, aligning course objectives with industry requirements, and ensuring equitable access to technology-enhanced learning resources. These challenges are critical considerations for effective business school collaboration through technology parks. Despite the challenges, the results also reveal significant opportunities for collaboration. Successful industrial partnerships, fluid technology programs, entrepreneurship programs, and various collaborative activities help improve students' practical experience and employability (Purnamawati, 2018, 2019; Valli et al., 2014).

Collaboration trends show that guest teachers, curriculum synchronization, curriculum validation, facilities and infrastructure implementation, teacher practices and corporate social responsibility initiatives are areas where business schools are actively engaging with stakeholders (Ramadhani & Rahayu, 2021; Sumbodo & Rahadjo, 2018). These trends illustrate several collaborative efforts to enrich the educational experience and prepare students for the workforce.

D. Conclusion

In conclusion, the research findings emphasize the transformative impact of Technopark initiatives, notably the Center of Excellence model, on curriculum enhancement, students' diversified skills, and character development in vocational schools. While challenges exist, the opportunities presented by collaboration and students' positive perceptions highlight the potential of Technoparks in shaping a more dynamic and industry-relevant vocational education landscape. Addressing challenges and leveraging collaborative opportunities will be crucial for sustaining and further improving the effectiveness of these initiatives.

The synthesis of findings culminates in developing a comprehensive

framework for sustainable vocational school development within the Technopark paradigm. This framework provides actionable guidance for policymakers, educational institutions, and industry stakeholders, offering a roadmap for optimizing Technopark initiatives to meet the evolving needs of vocational education. It serves as a valuable resource for stakeholders aiming to replicate and enhance the success of the CoE model in different vocational settings.

Acknowledgement

We express our heartfelt gratitude to all those who have contributed to the successful completion of this research study on the impact of integrating Technopark initiatives, specifically the Center of Excellence (CoE) model, into vocational schools. We sincerely thank the principals and teaching factory coordinators of the participating vocational schools for their invaluable insights, cooperation, and willingness to share their experiences.

Their commitment to innovation in education and dedication to preparing students for the future have been instrumental in shaping the outcomes of this study. We are indebted to the students who participated in the study, offering their perceptions and experiences. Their candid responses have provided a crucial understanding of the impact of Technopark initiatives on their skills, character development, and overall educational journey.

We appreciate the dedicated researchers and assistants in data collection, analysis, and interpretation. Their meticulous efforts and commitment to the research objectives have been instrumental in ensuring the credibility and depth of the study. This study represents a collective effort, and each contribution, no matter how small, has played a significant role in shaping its outcomes. We sincerely appreciate all individuals and entities involved for their unwavering support and collaboration.

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