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Developing Strategies to Enhance Vocational Inventors Using the SWOT Analysis and TOWS Matrix Methods

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Abstract

This research aims to (1) analyze the internal strengths and weaknesses of the National Research Council of Thailand (NRCT), as well as external environmental factors influencing the development of vocational inventors with innovative competencies; and (2) formulate strategic approaches to enhance the capabilities of vocational inventors. Adopting a qualitative methodology, the study gathered data through focus group discussions with 10 key informants actively involved in and responsible for the mission of developing vocational inventors. The SWOT framework was employed to assess the internal and external factors impacting the NRCT's efforts in this domain. Subsequently, a strategic brainstorming session with 8 experts—including corporate executives and innovation specialists—was conducted to generate strategic directions using the TOWS Matrix method. The analysis identified a comprehensive set of strengths, weaknesses, opportunities, and threats that served as the foundation for the TOWS-based strategic formulation. As a result, four strategic alternatives comprising thirteen strategies were developed: (1) four SO (Strength–Opportunity) strategies, (2) three ST (Strength–Threat) strategies, (3) four WO (Weakness–Opportunity) strategies, and (4) two WT (Weakness–Threat) strategies. These strategies aim to systematically strengthen the capacity of vocational inventors, ensuring alignment with both institutional capabilities and external innovation demands.

Introduction

The development of research and innovation personnel is imperative for advancing national progress in a rapidly evolving global economy and society. Skilled individuals specializing in research and innovation play a vital role in creating new inventions, addressing pressing challenges, and fostering sustainable national development (Toraksa, 2016) At the vocational education level, research and innovation personnel—including researchers, inventors, and innovators—serve as critical drivers of economic and social development. They contribute by cultivating a workforce that aligns with labor market demands, developing novel technologies, and positioning Thailand as a competitive player in the global landscape. Moreover, these efforts enhance the population's quality of life by delivering innovative products and services and resolving various societal challenges (Chantrachit, 2018) However, current

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limitations–including constrained budgets, insufficient equipment, inadequate tools, and a shortage of skilled personnel—have hindered the efficiency of vocational education in fostering innovative capabilities among students. Addressing these resource constraints is essential for empowering vocational inventors to attain high standards and meet the future needs of society and industry (Pandam, 2020).

The National Research Council of Thailand (NRCT), operating under the Ministry of Higher Education, Science, Research, and Innovation, fulfills its mandate in accordance with relevant policies and strategies aimed at fostering the development of research and innovation personnel across all levels. This includes researchers and inventors at the high school level, vocational education level, as well as new researchers, mid-career researchers, and senior researchers (National Research Council of Thailand, 2023). Among these groups, vocational students and instructors are identified as pivotal contributors, serving as foundational drivers of national progress in both economic and societal dimensions. (Pandam, 2020). The National Research Council of Thailand implements diverse mechanisms to advance the research and innovation capabilities for vocational inventors. These initiatives include fostering knowledge and understanding, guiding the preparation of project proposals, inspiring innovations and invention development, refining presentation techniques, as well ideas as encouraging the transformation of ideas into inventions and innovative applications. Furthermore, the NRCT organizes activities aimed at cultivating project managers, inventors, and innovators within vocational education. These individuals play a vital role in supervising supporting and promoting students' efforts to develop sustainable innovations and inventions (National Research Council of Thailand, 2023). Such activities are strategically designed to empower vocational developers establishing a strong foundation for enhancing the quality and impact of future innovative creations and inventions (Pandam, 2020). Innovations and inventions that have undergone thorough evaluation by qualified and experienced experts are recognized at both national and international levels. These selected works receive financial support through the Invent Plus project, an initiative led by the National Research Council of Thailand. The primary aim of this project is to enhance the quality and standards of vocational educational-level innovations, ensuring their readiness for technological and societal applications. Additionally, the initiative promotes versatility by advancing innovations that address multiple dimensions, including community impact, academic contributions, and commercial potential. The National Research Council of Thailand hosts the I-New Gen Award stage annually as part of the Inventor's Day, held from February 2 to 6. This platform offers vocational students a valuable opportunity to showcase their innovative work in a competitive environment. Winners are awarded trophies, cash prizes, and certificates, along with funding to present their projects on an international stage, thereby further promoting their contributions and strengthening Thailand's presence in global innovation. Since 2013, the development of vocational-level inventors has demonstrated a substantial increase in the number of innovative projects with the potential to progress to higher Technology Readiness Level (TRL) or Societal Readiness Level (SRL), particularly between levels 4 and 7. Notably, certain projects have shown the capability to advance even further, reaching the highest readiness levels (TRL8-9 or SRL8-9), enabling industrial-scale production or practical real-world applications. Despite progress in innovation development, many inventions have yet to reach the stage where they can be utilized across diverse dimensions. These creations require further advancement to realize their full potential. If vocational level inventors are cultivated into new-generation innovators with the skills to enhance and refine their work, the development of inventions achieving higher Technology Readiness Levels (TRL) and Societal Readiness Levels (SRL) would significantly elevate their capabilities. Such advancements would align vocational inventors with the evolving needs of the labor market while fostering the development of new technologies to improve the quality of life for the population. Consequently, it is essential to devise strategies to strengthen vocational innovators as a means to address these challenges. This research seeks to analyze the strengths, weaknesses, and external environment of the Vocational Education Commission in nurturing vocational inventors who excel in innovation and strategic management. The ultimate objective is to develop a skilled workforce of vocational inventors, proficient in research and innovation, with the capability to play pivotal roles in advancing the economies of communities, societies, and the nation. Through inventions, innovation, and creative thinking, these vocational inventors are envisioned to contribute significantly to future economic and societal development.

Objectives

1. To examine the strengths and weaknesses of the National Research Council and the external environment in its external environment in fostering the development of vocational inventors equipped with innovative competencies.

2. To formulate strategies aimed at enhancing and nurturing the capabilities of vocational inventors and cultivate vocational inventors.

Literature Review

1. Development of Research and Innovation Personnel of the Country

Policies and strategies concerning the development of research and innovation personnel are as follows:

1) The master plan under the National Strategy (23) for Research and Development of Innovation (2018-2037) aims to increase the quantity and quality of research and innovation personnel. It emphasizes the development of essential skills, including critical thinking, analytical skills, problem-solving and communication skills. Additionally. it supports the creation of research and innovation outputs that align with national priorities and address the country's developmental needs (National Economic and Social Development Board, 2018).

2) The 13th National Economic and Social Development Plan (2023-2027) focuses on advancing national development through social and human resources dimensions. It emphasizes the enhancement of human capital to align with the demands of the new global era, aiming to cultivate a highly skilled workforce the actively pursues continuous learning and adapts to future development needs. A key priority of the plan is accelerating the production of high-quality science and technology professionals whose expertise aligns with the country's strategic requirements (National Economic and Social Development Board, 2022).

3) The education policy on lifelong learning and reform presented by the Cabinet to the Parliament emphasizes educational reform and the establishment of a lifelong learning society. Key objectives of this policy include fostering good discipline and national pride among learners, enhancing their potential in alignment with individual aptitudes, and promoting reading as a tool for future development and income distribution. The policy also prioritizes broad access to education, the provision of appropriate learning tools for learners of all ages, and the integration of modern educational technology systems. Furthermore, it advocates for the design of curricula and tailored guidance based on learners' knowledge and interests, alongside the promotion of research and development in social sciences, applied science, advanced fields. This approach aims to drive progress in knowledge, technology, and innovation (Rohitsatien, 2023).

4) The Policy and Strategy for Integrated Education, Scientific Research, and Innovation 2023-2027 focuses on developing high-quality individuals equipped for lifelong learning. It prioritizes the cultivation of essential skills for necessary for advancing the economy and society while supporting the establishment of robust research and innovation ecosystems (Office of the Permanent Secretary, Ministry of Higher Education, Science, Research, and Innovation, 2023).

5) The Science, Research, and Innovation Development Plan of Thailand 2023-2027 aims to develop human resources and scientific research institutions as a foundational pillar for accelerating the country's economic and social progress in a leapfrog and sustainable manner. It emphasizes leveraging research, science and innovation to achieve these objectives (Office of the National Science, Research and Innovation Policy Council, 2023).

6) The Education Development Plan for Human Resource Production and Development of Thailand 2021-2027, revised for the period 2023-2027, serves as a framework for improving the quality of the education system. It focuses on fostering the development of human capital as a key factor in enhancing Thailand's competitiveness and promoting the sustainability of Thai society (Office of the Permanent Secretary, Ministry of Higher Education, Science, Research and Innovation, 2022).

2. Development of Research and Innovation Personnel of the National Research Council of Thailand (NRCT)

The National Research Council of Thailand (NRCT) plays a pivotal role in advancing the country's research and innovation ecosystem, Its responsibilities include for providing funding for research and innovation, establishing scientific databases and indexes, promoting and facilitating research activities nationwide, and initiating and coordinating important research and innovation projects. Additionally, the NRCT sets research standards and ethics, promotes the transfer and application of knowledge for societal benefit, supports the development of research and innovation personnel,

and recognizes outstanding contributions by individuals or organizations in the field of research and innovation. These efforts collectively aim to competitiveness, reduce social disparities, and improve the overall quality of life for the public. To achieve these objectives, the NRCT aims to continuously develop the nation's research and innovation personnel through the following targeted strategies (National Research Council of Thailand, 2023):

1) Developing Young Researchers

• Funding initiatives are aimed at promoting and supporting research activities through collaborative projects that enhance the practical applications of inventions. This includes co-funding mechanisms jointly financed by the National Research Council of Thailand (NRCT) and Office of the Vocational Education Commission (OVEC).

• Research and Innovation Support Fund, under the Invent Plus project, aims to elevate the quality and standards of vocational educational inventions. Its objective is to enhance and develop vocational inventions to meet high-quality standards, focusing on applications that benefit communities and the service sector.

• The Invention to Business project is designed to promote and develop research and innovation prototypes that are technologically prepared and meet established standards. It focuses on fostering intellectual property assets with practical applications that can benefit communities and the service sector. Additionally, the initiative supports the progression of these prototypes into startup ventures within the manufacturing, industrial, or commercial sectors.

• The Researcher Development Fund for graduate researchers focuses on enhancing the capabilities of research personnel at the master's and doctoral levels. It provides financial support for students and their advisors to facilitate research across diverse disciplines, including science, technology, engineering, medicine, social sciences, and humanities, fostering academic and professional grown in these fields.

• The Royal Golden Jubilee Ph.D. Program offers scholarships to support students undertaking doctoral studies at universities in Thailand. The program places particular emphasis on fostering research that contributes meaningfully to economic development, societal advancement, and academic excellence.

• The Researcher and Research Development for Industry Project (RRDI) provides funding aimed at advancing the skills of researchers and industrial personnel at the master's and doctoral levels. It addresses scientific and technological research challenges that align with industry needs, encourages problem-solving within industrial contexts, drives innovation, and facilitates the development of new technologies. Additionally, the initiative seeks to establish collaborative research networks that unite academic researchers and industry professionals for impactful results.

2) Promoting New Researchers

• The Young Researcher Development Project (Chick Program) supports graduate students to become motivated and proficient researchers.

• The New Researcher Development Project focuses on building research skills, analytical thinking, communication, and other essential competencies.

• The initiatives aim to spark students' interest in research by actively encouraging and nurturing their enthusiasm, inspiring them to engage in research, inventions, and innovations.

3) Potential Researcher Development

• The High Potential Researcher Development Project provides support to outstanding researchers, aiming to enhance the quality and impact of their research endeavors.

• The Postdoctoral Researcher Development Project concentrates on improving research skills and facilitating the production of high-quality research outputs.

• The initiatives include funding and opportunities for Thai researchers to conduct research abroad, facilitating knowledge exchange and further development of research competencies.

4) Innovation Workforce Development

• Enhancing creativity, management capabilities, and other essentials skills to cultivate innovative entrepreneurs.

• Providing personnel with expertise in technology transfer processes.

• Strengthening skills related to intellectual property asset management to ensure effective utilization and protection of innovations skills.

5) Building Collaborative Networks

• Establishing partnerships with public, private, and societal organizations as well as international research and innovation institutions to support the development of research and innovation personnel.

• Organizing and/or hosting conferences, seminars, and research presentation platforms to promote knowledge exchange and strengthen the capabilities of individuals in the fields of research and innovation

These strategies are designed to expand the pool of high-quality researchers and innovation personnel, improve the quality and impact of Thailand's research and innovation outputs, and enhance the nation's competitiveness in these fields . Ultimately, they aim to influence the country's overall productivity, which is a critical determinant of future competitiveness rankings.

3. Development of Research and Innovation Personnel of Office of the Vocational Education Commission (OVEC)

The Vocational Education Development Plan 2017-2036 is linked to the strategies for vocational education development, which include: 1) managing vocational education to ensure societal and national stability; 2) producing and developing human resources in vocational education to enhance the country's competitiveness; 3) enhancing the capabilities of vocational education personnel to align with national development needs; 4) creating opportunities, equity, and equality in access to vocational education; 5) managing vocational education systems to promote a quality of life that is environmentally friendly; and 6) improving the efficiency of vocational education management systems. These strategies aim to enhance the quality and increase the competency levels of vocational education graduates in areas such as desirable characteristics, core competencies, general competencies, professional competencies, and vocational education values, including ethics, quality, collaboration, and professionalism (Office of the Vocational Education Commission, 2017).

The strategy for producing and developing human resources in vocational education to boost the country's competitiveness includes the following approaches: 1) producing and developing vocational education personnel with competencies in fields that meet the demands of stakeholders and contribute to the country's economic and social development. 2) promoting the production and development of vocational education personnel who excel and specialize in their respective disciplines, and 3) encouraging research, innovation, technology, and knowledge creation within vocational education to increase productivity and generate greater economic value. The strategy for enhancing the capabilities of vocational education personnel to align with the country's development needs includes 1) promoting and supporting the development of vocational education personnel with desirable characteristics, core competencies, general competencies, and full professional competencies and 2) promoting the development of teachers and vocational education personnel to strengthen their capabilities (Office of the Vocational Education Commission, 2017). Developing research and innovation personnel is essential to driving the advancement of vocational education to meet the demands of the current job market and economy. OVEC prioritizes continuously enhancing the capabilities of personnel in this field, and has outlined the strategies for developing research and innovation personnel.

The strategies for developing research and innovation personnel include three key areas:

1) Skills and Knowledge Development

- Support personnel to participate in training, workshops, and study visits both domestically and internationally.
- Conduct hands-on training on research skills, writing research articles, research management, and other related topics.
- Develop specialized training courses tailored to specific needs.
- Promote personnel to publish research papers in academic journals.
- Support personnel to participate in academic conferences.

2) Research Promotion

- Provide research funding to researchers.
- Establish research centers/units to encourage collaboration.
- Develop a research database system for streamlined access to information.
- Link research activities with the private sector and other organizations to ensure practical applications.

3) Incentive Creation

- Award researchers with outstanding achievements to recognize excellence.
- Develop a research performance evaluation system to ensure quality outputs.
- Support personnel in utilizing research outcomes effectively to achieve societal and economic benefits.

The Vocational Education Development Plan aims to ensure that personnel possess current research and innovation skills and knowledge, produce high-quality research outputs that contribute to vocational education development, and encourage collaboration between vocational education institutions, the private sector and other organizations.

4. Essential Skills for the 21st Century (21st Century Skills)

The skills required in the 21st century refer to a set of knowledge, abilities and attributes essential for individuals to thrive in learning, work, and daily life. These skills are crucial in helping with continuously learning, adapting effectively to new situations, collaborating seamlessly, thinking critically, solving problems, making sound decisions, leveraging diverse digital technologies, driving innovation, maintaining self-discipline, taking responsibility for oneself, others, and society. These skills can be broadly classified into three main categories as follows:

1) Learning and Innovation Skills

• Critical Thinking and Problem Solving: The ability to analyze information, think logically, identify solutions, and effectively solve a range of problems.

• Creativity and Innovation: The capacity to think creatively, approach challenges with out-of-the-box ideas, and generate innovative solutions.

• Communication and Collaboration: The skill to express thoughts and information clearly, work effectively within a team, and collaborate harmoniously with others.

• Information, Media, and Technology Literacy: The knowledge and ability to understand and utilize various digital technologies for learning, working, and everyday activities.

2) Life and Career Skills

• Flexibility and Adaptability: The capacity to adjust to new circumstances, embrace continuous learning, and effectively cope with changes.

• Responsibility and Ethics: The ability to take responsibility for oneself, others, and society, upholding ethical standards, and remain steadfast in doing what is right.

• Self-Discipline: The skill to control oneself, manage time efficiently, and accomplish tasks effectively.

• Goal Setting in Life: The understanding of one's aspirations, setting meaningful life goals, and devising plans to achieve them.

3) Comprehension Skills and Using Digital Technology

• Information, Media, and Technology Literacy: The ability to comprehend and effectively use various digital technologies for learning, working, and daily life.

• Computational Thinking: The capacity to analyze, solve problems, and innovate by leveraging digital technologies.

• Cybersecurity: Knowledge of and adherence to cybersecurity practices to safeguard oneself and protect personal data.

These play an essential role in equipping individuals to excel in the 21st century. By possessing these abilities, individuals can foster lifelong learning, navigate changes and challenges with agility, collaborate effectively with others, and ultimately reach their full potential in both professional and personal realms.

The tool used in SWOT Analysis focuses on analyzing the situation comprehensively. It incorporates modern management techniques, such as the McKinsey 7s Framework to evaluate strengths and weaknesses within the organization. Additionally, PEST Analysis is utilized to examine opportunities and threats arising from the external environment. To identify and select appropriate strategies, the TOWS Matrix Analysis is applied, enabling a structured approach to align with internal and external factors effectively. The following provides a detailed overview of these techniques and their applications:

5. General Environmental Analysis (PEST Analysis)

The PEST Analysis examines changes in economic, political, social and technological conditions that create both opportunities and challenges for organizations. These changes influence competition, strategy formulation, decision-making and overall operations.(Wheelen and Hunger, 2002). It consists of the following elements:

1) Political: Evaluates changes in political conditions that may impact business operations.

2) Economic: Assesses economic factors such as inflation, interest rates, investment risks that may affect business performance.

3) Social: Analyzes societal trends, cultural shifts, and lifestyles changes that influence organizational strategies.

4) Technological: Reviews advancements in technology, innovation, and the potential risks associated with the loss of technological diversity.

6. Analysis of Strengths, Weaknesses, Threats, and Opportunities (SWOT Analysis)

SWOT analysis is a strategic tool used to evaluate the situation of an organization, business, or project by assessing internal and external factors to

identify strengths, weaknesses, opportunities, and threats. The insights obtained from a SWOT Analysis are valuable for formulating strategies and planning, making informed decisions and efficiently solving problems. It consists of:

1) Strengths: Qualities or advantages that an organization possesses.

2) Weaknesses: Limitations or drawbacks within the organization, such as limited resources, inadequate capabilities, outdated technologies, or a bad reputation.

3) Opportunities: External factors that are support the organization's success, including new markets, emerging trends, favorable government policies or evolving customer needs.

4) Threats: External factors that pose challenges to the organization, such as increased competition, disruptive technologies, regulatory changes, or economic downturns.

7. Modern management techniques based on the McKinsey 7s Framework

The success of effective management is based on seven interconnected variables (Teepapal, 2002), which include:

1) Strategy: Operations designed to create and sustain competitive advantage

2) Structure: A representation of the organization's work flow and hierarchy.

3) Systems: Process and directions guiding the organization's workflow.

4) Shared values: Core values upheld collectively by individuals within the organization.

5) Skills: Knowledge and expertise that form the organization's strengths and enabling successful implementation of strategies.

6) Staff: The members of the organization who contribute to its growth and objectives.

7) Style: The approach managers take in spending time, paying attention, and managerial responsibilities.

8. Analysis of appropriate strategies with TOWS Matrix Analysis

The TOWS Matrix is a strategic tool developed from SWOT Analysis used to analyze strengths, weaknesses, opportunities and obstacles collectively to identify suitable strategic approaches for an organization. It provides four strategic alternatives (Wheelen and Hunger, 2002).

1) SO Strategy: This strategy aims to leverage strengths and opportunities to achieve organizational goals. Weaknesses are addressed to transform them into strengths, while obstacles are converted into opportunities.

2) WO Strategy: Focuses on minimizing weaknesses while maximizing opportunities to enhance organizational potential.

3) ST Strategy: Targets situations where the organization possesses strengths but faces external obstacles. The strategy seeks to capitalize on strengths while minimizing obstacles.

4) WT Strategy: Deals with scenarios where the organization has both weaknesses and external obstacles. The goal is to build strengths and eliminate or reduce obstacles.

Conceptual Framework

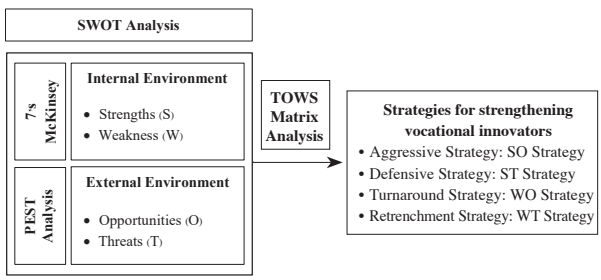

Figure 1 Conceptual Framework

Research Methodology

This research employs a qualitative research methodology and is conducted as follows:

1. Population and Sample

The population includes government officials, teachers, and education personnel serving as teachers and assistant teachers under the supervision of the Committee on Vocational Education. It also comprises of managers of educational institutions, government officials, and staff from the Ministry of Education (MoE) involved in the development of vocational inventors, as well as managers from the MoE Additionally, the population includes qualified individuals with expertise and experience in creating innovative works and innovations recognized at both national and international levels.

The selection of a sample group comprising of key informants for SWOT Analysis will be conducted using modern management methodologies in alignment

with the McKinsey 7s Framework to evaluate the internal strengths and weaknesses of the organization. Moreover, the PEST Analysis framework will be applied to assess external opportunities and threats. The selection process will deviate from statistical randomness, opting instead for a non-probability sampling strategy. Specifically, purposive sampling will be employed, to pinpoint relevant individuals and stakeholders who possess the expertise and insights necessary for the analysis. The objective is to implement the initiative aimed at nurturing 10 vocational education innovators. This includes three educators and educational personnel serving as teachers and assistant teachers under the Office of the Vocational Education Commission (OVEC), amounting to two individuals. Additionally, it incorporates two executives from OVEC Civil servants and officials from the NRCT are also part of the initiative, along with two executives from NRCT. Finally, three highly skilled individuals possessing specialized expertise and experience in developing inventions and innovations recognized both nationally and internationally contribute to the initiative. A focused brainstorming session will be held to develop a management strategy aimed at improving the skills of vocational education innovators. This session will utilize the TOWS Matrix analysis technique through concentrated group discussions with eight key informants. The informants will consist of: 1) two OVEC executives; 2) one NRCT executive; and 3) five highly-skilled individuals with extensive expertise and experience and more than five years of experience in the creating inventions and innovations recognized nationally and internationally.

2. Research Tools

This research utilized a semi-structured interview format as the principal tool for conducting the SWOT Analysis. The interview included questions address: 1) the strengths and weaknesses of the current development tasks of vocational inventors and 2) opportunities, challenges, and external factors affecting the management of the vocational inventor development tasks. Additionally, the TOWS Matrix was employed with questions such as 1) *How can the organization achieve its objective of fostering a vocational innovator workforce?* and 2) *What strategies can be developed to support this goal?* All questions were open-ended and were reviewed by a panel of experts for content and wording consistency.

3. Data Collection

Focus group discussions were conducted using the semi-structured interview format to examine the strengths, weaknesses, opportunities, and challenges impacting the development of vocational inventors in all dimensions. Additionally, brainstorming sessions were organized to determine management strategies aimed at fostering vocational inventors, involving key data providers as contributors to the discussions.

4. Data Analysis

Data obtained from the sub-group discussions (focus groups) were analyzed using content analysis methods that are effective for deriving meaning from various sources such as open-ended responses, dialogue content, to better understand the phenomena (Elo & Kyngäs, 2008). The process involves segmenting the responses from each participant into meaningful components based on a conceptual framework, followed by interpreting these components to identify relevant points aligned with the research objectives. Next, categories are established by transforming the meanings, emotions, and associated ideas in the text into codes (Weber, 1990). Irrelevant data are excluded to maintain alignment with the research questions, while relevant codes are grouped to form themes that represent the core essence of the findings. These themes are then named, and in the final stage of content analysis, the key points are summarized within the defined content scope, processed and organized into categories. This approach helps to establish interconnected relationships between concepts, interpret data types effectively, and then report outcomes in accordance with the research objectives.

Results

Through the focus group discussion conducted with the selected sample group, an evaluation of the strengths, weaknesses, and external environment of the National Research Office (NRCT) in relation to the advancement of vocational inventors has been undertaken. This assessment employes contemporary management techniques, specifically the McKinsey 7s Framework and PEST Analysis. The factors evaluated are categorized into two types: 1) internal factors, including strengths and weaknesses, and 2) external factors, including opportunities and threats originating from the external environment. The findings are summarized in the SWOT analysis as presented in Tables 1 and 2.

Table 1 Internal factors of the National Research Institute (NRI) related to the enhancement of vocational inventors

Strengths	Weaknesses
S1. The National Research Council of Thailand (NRCT) has a mission to promote and support the continuous development of research and innovation personnel.	W1. The absence of a system to track activity outcomes and a database system for recording performance results of vocational education level inventor development activities, hindering effective planning for future initiatives to enhance vocational inventors.
S2. Organization managers are committed to prioritizing and supporting activities that encourage invention and innovation across all levels.	W2. The lack of project management system to oversee vocational education-level invention and innovation activities, preventing efficient tracking, monitoring, and development of effective vocational inventors post-activities.
S3. Personnel within the organization possess extensive experience and expertise in organizing initiatives that foster invention and innovation.	W3. There is insufficient motivation and inspirational incentives to encourage engagement in vocational inventor development projects.
S4. There NRCT boasts qualified individuals with specialized knowledge and significant experiences in creating innovative works and innovations recognized both nationally and internationally, This includes experts, from various fields who contribute to the advancement of innovation.	W4. Limited integration of vocational education-level inventions and innovations to benefit the industrial or private sector stakeholders interested in utilizing them.
S5. Budget allocation is consistently provided to support activities that promote invention and innovation at the vocational education level.	W5. Ineffective public relations channels and insufficient awareness-building efforts for vocational inventor development projects.
S6. A robust coordination system is in place with external agencies engaged in research and innovation development.	W6. The lack of emphasis on equipping vocational teachers with research and innovation skills and knowledge relevant to the current era, preventing them from serving as effective mentors and knowledge facilitators for vocational students.
S7. The organization has established a strong network with vocational institutions nationwide, facilitating support for various aspects of promoting invention and innovation at the vocational education level.	W7. The absence of formal evaluation framework to assess the outcomes of inventor development activities.
S8. There is an extensive network of researchers and inventors both domestically and internationally, fostering collaboration and the exchange of knowledge.	

Table 2 Factors of the external environment related to the enhancement of vocational inventors

Opportunities	Threats
O1. The national strategic master plan focuses on promoting and supporting the continuous development of research and innovation.	T1. Budget constraints and a lack of skills among vocational education personnel in research, innovation, and creative outputs hinder progress.
O2. The education development plan (2021-2027) and the vocational education development plan (2017-2036) include policies and strategies aimed at cultivating high-quality research and innovation personnel.	T2. Changes in government administrations and economic conditions pose potential challenges to sustaining research and innovation funding.
O3. The advancement of digital technology and increased internet accessibility provide vocational students with expanded learning opportunities. These advancements enable students to observe exemplary innovations, inspiring creativity and innovative thinking to advance their own work.	T3. Detailed and complex research standards require expertise for effective transfer and teaching, creating an additional barrier..
O4. The private sector acknowledges the importance and advantages of leveraging inventions and innovations to enhance their competitiveness. This recognitions drives partnerships, financial support, and collaborative efforts with education institutions in research and innovation development.	T4. Commercializing innovations demand compliance with various standards and necessitates collaboration with production facilities and the private sector.
O5. Favorable environmental conditions and evolving social dynamics contribute to the development and enhancement of human resources' potential in research and innovation.	T5. Insufficient knowledge in advancing inventions and innovations to a technologically ready stage limits their practical application.
O6. Vocational education personnel possess knowledge, skills, experience, and expertise across various professional fields, strengthening the foundation for innovation and development.	T6. Weak connections between the education system and the labor market impede the alignment of vocational skills with industry demands.
	T7. Inadequate infrastructure within vocational education institutions fails to provide adequate support for research and innovation development.

The TOWS Matrix analysis is then conducted as a tool for generating new strategies tailored to the organization's environment and current situation. Building upon the foundation of the SWOT Analysis, the TOWS Matrix pairs internal factors (strengths and weaknesses) with external factors (opportunities and threats) to create comprehensive strategies. By pairing these internal and external factors, the TOWS Matrix analysis produces four strategic formats designed to enhance vocational inventors, as follows:

1) Aggressive Strategies (SO strategy)

Aggressive strategies focus on leveraging strengths to capitalize on opportunities. They include the following:

SO1. Develop training programs and activities to enhance innovation and creativity skills. These programs focus on imparting knowledge essential for the 21st century, ensuring vocational inventors are well-prepared to meet industry demands.

SO2. Foster collaborative networks among the National Research Council of Thailand (NRCT), vocational education institutions, private sectors, and research agencies. These networks aim to create opportunities for skill development, innovation, and experiential training for vocational inventors.

SO3. Drive the commercialization of innovative outputs by pairing businesses with vocational inventors. This collaboration supports funding and facilitates the utilization of innovation in multiple dimensions including community, social, academic, and commercial sectors.

SO4. Promote international cooperation between vocational inventors and foreign inventors. Such collaborations facilitate the exchange of knowledge, technology, and experiences, enriching the innovation ecosystem.

2) Defensive Strategies (ST)

The defensive strategies aim to use internal strengths to address external threats. These include:

ST1. Enhance the research and innovation capabilities of vocational education personnel by implementing a mentoring system. This system would involve guidance from qualified experts and experienced individuals recognized nationally and internationally for their contributions to innovation development.

ST2. Elevate vocational inventors' inventions and innovations to advanced technological readiness level or societal readiness levels, reaching a maximum potential for industrial production or practical application (TRL8-9 or SRL8-9).

ST3. Establish collaborative networks between vocational education institutions and industry partners These networks would focus on securing research funds and providing essential resources, laboratories, equipment, and tools to support vocational inventors in their developmental journey.

3) Turnaround Strategies (WO strategy)

The turnaround strategies focus on addressing weaknesses by capitalizing on opportunities. These include:

WO1. Develop a robust tracking and evaluation system along with a performance database for vocational inventor enhancement activities. This system will support effective planning and continuous improvement.

WO2. Create a comprehensive project management system for innovators' managers to efficiently oversee, track, and develop vocational inventors. This system will involve consultation with qualified experts and experienced individuals recognized nationally and internationally for their contributions to innovation development.

WO3. Promote competitions, contests, and recognition programs for vocational inventors at national and international stages. These initiatives aim to inspire participation and motivate engagement in projects focused on vocational inventor development.

WO4. Strengthen the image and effectiveness of public relations channels to boost awareness and encourage participation in vocational inventor enhancement projects.

4) Retrenchment Strategies (WT)

Retrenchment strategies focus on addressing weaknesses while minimizing threats. These include:

WT1. Develop training programs that incorporate appropriate tools aligned with current trends to enhance the capabilities of trainers and mentors responsible for guiding vocational inventors.

WT2. Establish online and social media channels for vocational inventor enhancement projects. These channels aim to publicize initiatives, raise awareness, and facilitate the exchange experiences among vocational education personnel, relevant organizations, and the industrial sector.

Conclusion

The SWOT analysis of the National Research Council of Thailand (NRCT) regarding its management in enhancing vocational inventors identified key strengths, weaknesses, opportunities, and threats. These findings have been utilized to analyze the TOWS Matrix, which serves as a basis for developing strategies aimed at improving vocational inventors.

A total of 13 strategies have been devised, categorized into four types: (1) Aggressive Strategies (SO strategy) comprising four strategies, (2) Defensive Strategies (ST strategy) with three strategies, (3) Turnaround Strategies (WO strategy) comprising four strategies, and (4) Retrenchment Strategies (WT strategy) with two strategies.

The strategies for enhancing vocational inventors derived from this research provide valuable guidelines for developing human resources, processes, and policies. These strategies aim to empower vocational inventors with innovative capabilities, ensuring they become high-quality personnel who play significant roles in creating impactful innovations and driving the economic growth of communities, societies, and countries. A summary of these strategies for enhancing vocational inventors is shown in Figure 2.

Internal Environment / External Environment	Strengths (S)	Weakness (W)
	1. NRCT supports research and innovation 2. Budget allocation for activities 3. Strong vocational institution network 4. Connections with researchers and inventors 5. Efficient coordination system 6. Leadership prioritizes invention and innovation 7. Experienced and expert personnel 8. Qualified experts/instructors	1. No follow-up mechanism or project repository. 2. Lack of structured project management. 3. No formal strategy for outcome evaluation. 4. Insufficient professional development for educators. 5. Lack of incentives for project engagement. 6. Poor integration of inventions and innovations.
Opportunities (O)	**Aggressive Strategy (SO strategy)**	**Turnaround Strategy (WO strategy)**
1. National strategies integrating higher education and vocational training effectively support and advance research and innovation. 2. The private sector actively invests, provides financial assistance, and forms collaborative partnerships with educational institutions. 3. Societal transformations drive progress in research and innovation. 4. Vocational professionals exhibit expertise across a wide range of specialized disciplines. 5. Advancements in digital technology and improved internet accessibility broaden opportunities for innovation. 6. The emergence of new technologies and groundbreaking innovations accelerate development.	SO1. Design educational programs and initiatives that emphasize 21st-century knowledge and equip educators with essential competencies for implementing advanced pedagogical methodologies. SO2. Develop collaborative networks to strengthen partnerships and foster cooperation among key stakeholders. SO3. Establish a structured framework to facilitate the commercialization of innovations through strategic business collaborations. SO4. Encourage synergies between domestic vocational inventors and their international counterparts to exchange knowledge, technology and experiences.	WO1 Establish a robust tracking system, evaluation framework, and database to systematically document project outcomes for effective analysis and future planning. WO2 Enhance the professional development of vocational educators through the implementation of a structured mentorship program supported by experienced mentors. WO3 Organize competitions, contests, and awards programs to recognize the achievements of vocational innovators. WO4 Bolster the organization's reputation and public relations efforts to increase awareness, encourage engagement, and attract participation.
Threats (T)	**Defensive Strategy (ST)**	**Retrenchment Strategy (WT)**
1. Research principles are complex and multifaceted, posing challenges for effective execution. 2. Commercial innovations must meet stringent standards to be market ready. 3. A persistent gap exists between the educational system and the job market. 4. Vocational education institutions face financial constraints limiting research and innovation. 5. Inadequate infrastructure in vocational education hampers research and innovation development. 6. Vocational education personnel lack essential skills for conducting research and fostering innovation.	ST1. Strengthen professional development through an organized mentoring structure. ST2. Advance inventions and innovations to achieve optimal Technology Readiness Level (TRL) or System Readiness Level (SRL). ST3. Cultivate collaborative partnerships between vocational training institutions and the industrial sector.	WT1 Design state-of-the-art skill enhancement curricula and integrate modern tools to empower NRCT educators in delivering effective training. WT2 Create digital media platforms to support initiatives that promote vocational inventors, enhance awareness, and facilitate experience sharing among vocational professionals, related organizations, and industry stakeholders.

Figure 2 Strategies for enhancing vocational inventors

Discussion

The implementation of vocational inventor development initiatives from 2013 to the present has demonstrated that numerous inventions possess significant potential to progress to higher levels of technological readiness (TRL) or social readiness (SRL). However, vocational inventors face limitations in realizing their innovative potential due to the absence effective methodologies for transforming them into high-caliber research and innovation professionals. Such professionals are essential for advancing the economic growth of communities, societies, and the nation through their creativity, innovations, and inventions. To address this, contemporary management frameworks, aligned with the McKinsey 7s Framework, were employed to evaluate the strengths and weaknesses of the National Research Council of Thailand (NRCT), the governing entity for vocational invention and innovation initiatives (Amin et al., 2011). Additionally, PEST Analysis was utilized to assess external opportunities and challenges (Chang and Huang, 2006). The outcomes of these evaluations were incorporated into a TOWS Matrix analysis, facilitating the development of strategies that amalgamate external opportunities and challenges with the organization's internal strengths and weaknesses (Dewanto, 2022). This comprehensive approach culminated in the formulation of a thorough strategic framework.

Aggressive Strategies include: SO1. Organize training courses and activities to enhance invention and innovation skills, emphasizing essential 21st century knowledge. These initiatives aim to equip vocational inventors to meet the demands of the industrial sector effectively; SO2. Develop collaborative networks among the NRCT, vocational education institutions, private sectors, and research agencies. These networks will create opportunities for skill development, invention creation, and experiential learning to empower vocational inventors; SO3. Establish a mechanism to facilitate the commercialization of inventions by matching businesses with vocational inventors. This collaboration will provide financial support funding and enable vocational inventors to apply their innovations across various dimensions, including community, society, academics, and commerce; SO4. Promote international cooperation by cultivating partnerships between vocational inventors and foreign inventors. These alliances will facilitate the exchange of knowledge, technology, and experiences to enrich the innovation ecosystem.

SO1 and SO2 prioritize 21st-century knowledge for vocational inventors, aligning with Panich (2012), who emphasized that the 21st century is a rapidly changing era where learning skills, creativity, and innovation are essential. These abilities, inherent in human nature, can be sharpened through effective training, leading to improved job prospects, societal contributions, and personal growth. Learners must also develop technological and problem-solving skills, as their exposure to digital environments has shaped unique thinking and information processing compared to previous generations. Success in the 21st century depends on adaptability, lifelong learning, and using information technology effectively to overcome challenges. Krathana (2022) highlighted that vocational education curricula should align with professional and career standards, emphasizing international practices, flexible learning structures, and skills relevant to working-age learners. Teachers should act as facilitators, integrating diverse learning methods, future technologies, and 21st-century skills to equip learners with vocational expertise.

SO3 and SO4 focus on creating mechanisms to bring inventions to the market by connecting businesses with vocational-level inventors and promoting collaboration between vocational-level inventors and foreign inventors. This aligns with Limsuwan (2018), who highlighted the importance of supporting vocational students to showcase their innovation capabilities and fostering cooperation with both domestic and international inventors. Such efforts have resulted in numerous practical and market-ready works. Krathana (2022) emphasized the significance of collaboration with establishments, outlining clear guidelines for setting objectives, workforce planning, education and training, monitoring, evaluation, and supporting research and inventions. These practices represent desired outcomes for vocational education management in the future.

Defensive strategies include developing vocational personnel with up-to-date research and innovation skills through a structured mentoring system led by nationally and internationally recognized experts in inventions and innovations (ST1). Another strategy focuses on advancing vocational inventions and innovations to achieve the highest levels of technological readiness (TRL8-9) or social readiness (SRL8-9), ensuring applicability in industrial production or practical use (ST2). Additionally, fostering cooperation between vocational institutions and the industrial sector is vital for securing research funding and resources, including

laboratories, equipment, and tools, to support vocational inventors (ST3). This aligns with Wimonporn (2020), who emphasized the importance of learning directors, tools, and materials in developing inventor areas in the Eastern Economic Corridor, which enhance innovator competence through modern tools and technologies. Pandam (2020) similarly highlighted the significance of inventor areas in stimulating innovation among vocational students, enabling the creation of practical inventions and facilitating start-ups that contribute to economic growth. By integrating such approaches, Thailand can move toward its Thailand 4.0 strategy, driving national development through innovation in a sustainable manner. Krathana (2022) reinforced the importance of collaborative policies, effective leadership, dual education systems, and the utilization of modern laboratories and equipment, ensuring vocational education management adapts to future demands and maximizes its potential.

Turnaround strategies involve creating a system for tracking, evaluating, and documenting activity results to facilitate effective planning for the development of vocational inventors (WO1). Another key strategy involves establishing an efficient project manager system for vocational invention and innovation initiatives, where vocational inventors are monitored and guided by nationally and internationally recognized experts in invention and innovation (WO2). Promoting competitions and honoring vocational inventors on national and international stages is another vital approach, as it inspires motivation and participation in vocational inventor development projects (WO3). Additionally, the enhancement of the organization's image and public relations efforts aims to create awareness and encourage engagement in these development initiatives (WO4).

These strategies align with Limsuwan (2018), who reported that driving vocational invention and innovation into the industrial and commercial systems has led to vocational student inventions being showcased in competitions and contests at provincial, regional, and national levels, fostering innovative competencies. Similarly, Krathana (2022) highlighted the importance of a robust measurement and evaluation system in future vocational education management, including consistent assessments based on professional standards, workplace satisfaction monitoring, and qualifications aligned with professional standards. Learners should possess essential skills such as knowledge creation, innovation, technology utilization, leadership, adaptability, and life skills, along with maturity and industrial habits. These competencies are critical for navigating challenges in vocational education and advancing organizational and societal goals.

Retrenchment strategies include creating skill-building courses and providing modern tools for trainers and mentors to effectively support the development of vocational inventors (WT1). Another strategy focuses on developing online and social media platforms for the vocational inventor development project to enhance publicity, build awareness, and facilitate experience sharing among vocational personnel, relevant agencies, and the industrial sector (WT2). These approaches align with Khajonsak et al. (2022), who emphasized that developing the competencies of researchers and inventors requires self-reflection or self-evaluation, alongside active integration into development systems through tools and strategies such as job training and expert-led training sessions. From all the alternative strategies, the organization's strategic positioning must be analyzed using data from the SWOT Analysis to identify potential strengths and areas for development. This involves determining the strategic position by calculating the sum of the weights of strategic factors within each area of the SWOT framework. The identified "strategic position" will guide the prioritization of specific strategies for implementation, ensuring the organization progresses toward its intended goals. Other strategies will serve as alternative approaches for developing vocational inventor seedlings, applied as deemed appropriate.

Recommendations of the Study

Recommendations for the Implementation of the Research Results

1. The National Research Council of Thailand (NRCT) should formulate strategies to enhance vocational inventors by focusing on human resources, processes, and policies the support the mission of advancing research and innovation capabilities for vocational inventors.

2. The National Research Council of Thailand (NRCT) should propose policy-driven strategies to gather stakeholder feedback and provide clear guidelines for the future development of vocational inventors.

3. The Office of the Vocational Education Commission (OVEC) should allocate essential resources and tools, develop policies supporting the integration of technology into teaching frameworks, and conduct regular evaluations of technology implementation to improve the effectiveness of educational practices.

4. The Office of the Vocational Education Commission (OVEC) is encouraged to enhance vocational educators' pedagogical competence by organizing workshops that underscore innovative pedagogical paradigms and methodologies, such as project-based learning, problem-based learning, collaborative learning, and the integration of digital technologies in education.

Recommendations for Further Studies

1. The outcomes of strategies aimed at enhancing vocational inventors in terms of human resources, processes, and policies can be analyzed to assess their impact on vocational inventor development.

2. The innovative capacity of vocational students who have participated in NRCT-organized activities to enhance vocational inventors can be studied and evaluated to measure their growth and contributions.

3. The Technology Readiness Level (TRL) and Societal Readiness Level (SRL) of products and innovations and developed by vocational students through NRCT activities can be monitored and evaluated for their applicability across various dimensions, including community, societal, academic, and commercial aspects.

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