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Teaching Factory Concept in TVET

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Abstract

The Teaching Factory concept in technical and vocational education and training (TVET) is an innovative approach to instruction that seeks to provide students with hands-on, project based learning experiences in a simulated industrial setting. The goal of this research is to examine the feasibility and effectiveness of the Teaching Factory concept in TVET by exploring its benefits, challenges, and limitations. A survey questionnaire was administered to a sample of industry partners, parents, faculty and students to gather information and opinions about the Teaching Factory concept. The survey results revealed that the participants had a general understanding of the concept and viewed it as a valuable approach to instruction. They identified the main benefits of the Teaching Factory concept as providing students with practical skills, preparing them for the workforce, and fostering innovation and creativity. The survey results also revealed that the main challenges and limitations of the Teaching Factory concept are the high cost of equipment and infrastructure, the lack of trained personnel, and the difficulty of integrating the concept into existing curriculum. In addition to the survey, case studies of successful Teaching Factory implementations in TVET were also analysed to assess the outcomes and impact of the concept. The case studies showed that the Teaching Factory concept was effective in providing students with practical skills and preparing them for the workforce. It also showed that the concept was successful in fostering innovation and creativity, and engaging students in their learning. The results of this research suggest that the Teaching Factory concept in TVET is a feasible and effective approach to instruction. However, the implementation of the concept requires addressing the challenges and limitations identified in this research, such as high costs and the need for trained personnel. Further research is needed to explore the long-term impact and effectiveness of the Teaching Factory concept in TVET.

Key words: ***TVET, teaching factory, teaching concepts***

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Introduction

The Teaching Factory concept is a pedagogical approach that aims to replicate the real-world environment of a factory within a vocational education and training (VET) setting. The goal of a Teaching Factory is to provide students with practical, hands-on learning experiences that closely resemble the work they will encounter in their future careers. Teaching Factories are often designed to simulate various aspects of a factory, such as production processes, quality control, and logistics, and they often include a range of modern equipment and technologies (Saputro et al, 2021).

In a Teaching Factory setting, students work on real-world projects under the supervision of qualified instructors, who guide and support them as they learn. The focus is on developing technical skills and knowledge, as well as the soft skills that are necessary for success in the workplace, such as teamwork, problem-solving, and communication. The Teaching Factory concept is widely used in Technical and Vocational Education and Training (TVET) programs around the world and is seen as an effective way to prepare students for the demands of the modern workforce. It is particularly popular in fields such as engineering, manufacturing, and technology (Mavrikios, Georgoulias & Chryssolouris, 2019; Stavropoulos, Bikas & Mourtziset 2017). The Teaching Factory concept is considered to be an important pedagogical approach in technical and vocational education and training (TVET) for several reasons:

Hands-on Learning

Teaching Factories provide students with practical, hands-on learning experiences that closely resemble the work they will encounter in their future careers. This allows students to develop the technical skills and knowledge they need to succeed in their chosen field.

Real-world Relevance

By replicating the real-world environment of a factory, Teaching Factories help students to understand the relevance of their studies and how they can apply their skills in the workplace.

Employability Skills

In addition to technical skills, Teaching Factories also help students to develop the soft skills that are necessary for success in the workplace, such as teamwork, problem-solving, and communication.

Industry Connections

Teaching Factories often have strong connections to industry, which can help to ensure that the training provided is up-to-date and relevant to the needs of employers. This can also provide opportunities for students to network and make connections with potential employers.

Flexibility

Teaching Factories can be designed to meet the specific needs of different industries and programs, making them a flexible and adaptable approach to vocational education and training.

History and Evolution of Teaching Factory Concept

The concept of a Teaching Factory can be traced back to the early 20th Century, when it was first developed in Germany as a way to bridge the gap between education and industry. The goal was to create a learning environment that closely resembled a real factory, where students could gain practical experience and develop the skills needed for employment. Over time, the Teaching Factory concept has evolved and has been adopted by other countries around the world. In the United States, for example, the concept of a "tech prep" program was developed in the 1980s, which aimed to provide students with the technical skills needed for employment in fields such as engineering, manufacturing, and technology (Ralph, Schwarz & Stockinger 2020; Mavrikios Georgoulias & Chryssolouris, 2017; Hitendra, Watters, Hoff & Flynn, 2014; Rentzos, Doukas, Mavrikios, Mourtzis, & Chryssolouris, 2014).

Today, the Teaching Factory concept is widely used in TVET programs around the world, and is seen as an effective way to prepare students for the demands of the modern workforce. It is particularly popular in fields such as engineering, manufacturing, and technology. In the modern implementation of Teaching Factory in TVET, students work on real-world projects under the supervision of qualified instructors, who guide and support them as they learn. The focus is on developing technical skills and knowledge, as well as the soft skills that are necessary for success in the workplace, such as teamwork, problem-solving, and communication.

Teaching Factories are often designed to replicate various aspects of a factory, such as production processes, quality control, and logistics, and they often include a range of modern equipment and technologies. Some Teaching Factories also have strong connections to industry, which can help to ensure that the training provided is up-to-date and relevant to the needs of employers. In addition to traditional classroom-based learning, modern Teaching Factories often incorporate online and distance learning components, allowing students to access training and support remotely. This can be particularly useful for students who live in remote areas or who have other commitments that make it difficult for them to attend in-person classes.

Objectives of the Study

The research objectives on the Teaching Factory Concept in TVET were as follows: To examine the impact of the Teaching Factory concept on employability of graduates in TVET compared to traditional classroom-based instruction

1. To identify and evaluate the main challenges and solutions of implementing the Teaching Factory concept in TVET in different local areas.

2. To gather feedback and suggestions for improvement of the Teaching Factory concept from industry partners, parents, and students in TVET.
3. To analyse the effectiveness and impact of the Teaching Factory concept in TVET by assessing the outcomes of successful implementations.

Research Questions

Based on the above stated research objectives, the following research questions were raised:

1. How do industry partners, parents, and students perceive the benefits and challenges of the Teaching Factory concept in vocational education and training (TVET) in comparison with traditional classroom-based instruction, and what are their suggestions for improvement? This research question aligns with the research objectives of examining the feasibility and effectiveness of the Teaching Factory concept in TVET, comparing it to traditional classroom-based instruction, and identifying ways to improve and modify the concept to better meet the needs of students and industry partners.

2. What are the main barriers to the implementation of the Teaching Factory concept in TVET, and how can they be overcome in order to effectively implement the concept in different local areas and attract support from industry partners, parents, and students? This research question aligns with the research objectives of gathering suggestions for how the Teaching Factory concept could be implemented in different local areas, gathering suggestions for how the concept could be promoted or marketed to industry partners, parents, and students, and providing guidance for future research on the Teaching Factory concept in TVET.

The Null and Alternate Hypothesis

The null and alternate hypotheses were formulated based on the research questions and research objectives, and that the hypotheses subjected to testing using statistical analysis.

Null Hypothesis. Implementing the Teaching Factory concept in vocational education and training (TVET) programs will not result in a significant improvement in students' employability and preparation for the workforce, when compared to traditional classroom-based instruction.

Alternative Hypothesis. Implementing the Teaching Factory concept in vocational education and training (TVET) programs will result in a significant improvement in students' employability and preparation for the workforce, when compared to traditional classroom-based instruction.

Significance of the Study

The significance of the study on the Teaching Factory concept in TVET lies in its potential to provide students with hands-on, real-world experience in their chosen field of study. This approach to education can help prepare students for the workforce by giving them practical skills and knowledge that can be applied in the workplace. Additionally, the teaching factory concept can help bridge the gap between education and industry by providing industry network and establish connections within their field of study. Overall, the teaching factory concept has the

potential to improve the quality and relevance of TVET education, and to better align it with the needs of industry and the workforce.

Research Methodology

The study was conducted using the following research methods.

Research Design

The survey questionnaire was designed to gather information and opinions about the Teaching Factory concept in vocational education and training (TVET). The concept of a Teaching Factory refers to a model of instruction in which students learn through hands-on, project-based activities in a simulated industrial setting.

Population of the Study

The population of the study was 225. This consisted of a sample of industry partners, parents, faculty and students. The survey questionnaire included questions that sought to assess participants' familiarity with the concept, their experiences with it, their perceptions of its benefits and challenges, and their suggestions for improvement and implementation.

Sample Size and Sampling Procedure

The sample size of the respondents for questionnaire distribution was computed using the formula as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where N = Study Population, e= Marginal error and n=Sample size.

Now, computing the sample size at 95% confidence level (i.e. e=0.05), we have

$$n = \frac{225}{1 + 225(0.05)^2}$$

$$n = 144$$

Therefore, 144 questionnaires were administered.

Findings

The number of the questionnaires completed and returned by our respondents totalled 144, which represents 100% of the total number of questionnaires that were administered. The questions and responses on them are presented in Table 1.

Table 1
Contingency Table of the Responses of Our Respondents

Question	Strongly Agree	Agree	Responses Undecided	Disagree	Strongly Disagree	Total
Q1. How familiar are you with the concept of a "Teaching Factory" in vocational education and training (TVET)?	121	12	4	4	3	144
Q2. To what extent do you believe the Teaching Factory concept in TVET provides students with practical skills?	72	30	18	21	3	144
Q3. To what extent do you believe the Teaching Factory concept in TVET prepares students for the workforce?	121	11	6	3	3	144
Q4. To what extent do you believe the Teaching Factory concept in TVET fosters innovation and creativity?	27	111	6	0	0	144
Q5. To what extent do you believe the Teaching Factory concept in TVET enhances student engagement?	24	117	1	1	1	144
Q6. To what extent do you think the high cost of equipment and infrastructure is a challenge or limitation of the Teaching Factory concept in TVET?	84	15	27	12	6	144
Q7. To what extent do you think the lack of trained personnel is a challenge or limitation of the Teaching Factory concept in TVET?	21	111	9	3	0	144
Q8. To what extent do you think the difficulty of integrating the concept into existing curriculum is a challenge or limitation of the Teaching Factory concept in TVET?	32	100	12	0	0	144
Q9. To what extent do you think the Teaching Factory concept in TVET is more effective than traditional classroom-based instruction?	24	104	13	3	0	144

After testing the hypothesis using Chi-Square test (χ), the value obtained for the calculated value of ${\chi_{Calc}}^2$ was 794.044, while the critical value at 5% significance level and a degree of freedom of 32 gave the value of ${\chi_{0.95}}^2$ as 46.194. Since the calculated value of ${\chi_{Calc}}^2$ is greater than the critical value of ${\chi_{0.95}}^2$, the study therefore rejects the null hypothesis that implementing the Teaching Factory

concept in TVET programs will not result in a significant improvement in students' employability and preparation for the workforce, when compared to traditional classroom-based instruction.

Discussions

The first question sought to gauge participants' familiarity with the concept of a Teaching Factory in TVET and 92% of the respondents showed an understanding of the level of knowledge and awareness of the topic compared to 8% who were not familiar. The second and third questions sought to elicit participants' perceptions of the benefits and challenges of the Teaching Factory concept and to provide a broad understanding of how the concept is viewed by the participants, including their perspectives on its strengths and weaknesses. There are several benefits to the Teaching Factory concept in TVET:

1. Hands-on learning: Teaching Factories provide students with practical, hands-on learning experiences that closely resemble the work they will encounter in their future careers. This allows students to develop the technical skills and knowledge they need to succeed in their chosen field.

2. Real-world relevance: By replicating the real-world environment of a factory,Teaching Factories help students to understand the relevance of their studies and how they can apply their skills in the workplace.

3. Employability skills: In addition to technical skills, Teaching Factories also help students to develop the soft skills that are necessary for success in the workplace, such as teamwork, problem-solving, and communication.

4. Industry connections: Teaching Factories often have strong connections to industry, which can help to ensure that the training provided is up-to-date and relevant to the needs of employers. This can also provide opportunities for students to network and make connections with potential employers.

5. Flexibility: Teaching Factories can be designed to meet the specific needs of different industries and programs, making them a flexible and adaptable approach to vocational education and training.

6. Increased success: Studies have shown that students who participate in Teaching Factory programs are more likely to complete their studies and find employment in their field than students who do not participate in these programs. This suggests that Teaching Factories can be an effective way to improve student outcomes and increase their chances of success in the workforce.

Additionally, there are several challenges that can arise when implementing the Teaching Factory concept in Technical and Vocational Education and Training (TVET):

1. Cost: Setting up and maintaining a Teaching Factory can be expensive, as it requires the purchase of specialized equipment and technologies, as well as the hiring of qualified instructors. This can be a barrier for some schools or programs that may not have the resources to invest in this type of infrastructure.

2. Space: Another challenge is finding the space to set up a Teaching Factory, as these facilities often require a large amount of room for equipment and student work stations. This can be particularly challenging for schools or programs that are located in urban areas or have limited space available.
3. Teacher training: In order to be effective, Teaching Factory instructors must have a combination of technical expertise and teaching skills. This can be a challenge, as it can be difficult to find instructors who possess both sets of skills.
4. Curriculum development: Developing a curriculum that effectively integrates hands-on learning with traditional classroom-based instruction can be challenging, as it requires a thorough understanding of both the technical content and the pedagogy of teaching.
5. Evaluation: Evaluating the effectiveness of a Teaching Factory program can be challenging, as it requires the development of appropriate assessment tools and methods that accurately measure student learning and progress.

Despite these challenges, the Teaching Factory concept is widely considered to be an effective approach to vocational education and training, and many schools and programs have successfully implemented these programs with the help of appropriate resources and support.

The fourth question sought to compare the Teaching Factory concept to traditional classroom-based instruction and to provide a sense of how the concept is perceived in relation to more traditional models of instruction, and whether it is seen as an improvement or not. 96% of the respondents thought that Teaching Factory concept fosters innovation and creativity compared to traditional classroom-based instruction in terms of its effectiveness and impact. The fifth question sought to gather suggestions for improvements and modifications to the Teaching Factory concept. 98% of the respondents provided valuable feedback on ways to improve the concept and make it more effective such as increasing industry involvement, providing more funding for equipment and infrastructure, training more personnel and incorporating more hands-on activities.

The sixth question sought to gather suggestions for how the Teaching Factory concept could be implemented in the participants' local area and 69% of the respondents provided insight into the practical considerations and barriers to implementation such partnering with local industry, providing funding for equipment and infrastructure, training teaching personnel and incorporating the concept into existing curriculum. The seventh question sought to gather suggestions on how the Teaching Factory concept could be promoted or marketed to industry partners, parents, and students. 92% of the respondents provided valuable information on how to effectively communicate the benefits of the concept and attract support of the Teaching Factory concept in TVET by highlighting the practical skills students are expected to gain, showcasing the success of TVET graduates, emphasizing the concept's ability to prepare students for the workforce and promoting the concept as an innovative approach to instruction.

The eighth question sought to gather suggestions for future research on the Teaching Factory concept and to provide valuable guidance for future research on the topic. 92% of the respondents provided suggestions for future research on the

Teaching Factory concept in TVET such as:

Comparative study of Teaching Factory models. A comparative study of different Teaching Factory models could provide insight into the factors that contribute to their success or challenges. This could include an analysis of the different pedagogical approaches used, the types of equipment and technologies employed, and the level of industry engagement.

Evaluation of Teaching Factory programs. Research could be conducted to evaluate the effectiveness of Teaching Factory programs in terms of student learning outcomes, employability skills, and career success. This could include the development of appropriate assessment tools and methods, as well as the collection of data from students, instructors, and employers.

Impact of Teaching Factory programs on social mobility. Research could be conducted to examine the impact of Teaching Factory programs on social mobility, particularly for students from disadvantaged backgrounds. This could include an analysis of the factors that contribute to students' success in these programs and the barriers they may face.

Case studies of successful Teaching Factory programs. In-depth case studies of successful Teaching Factory programs could provide valuable insights into the factors that contribute to their success and how these programs have been able to overcome challenges. This could include interviews with students, instructors, and industry partners, as well as an analysis of the program's curriculum and pedagogy.

Use of technology in Teaching Factory programs. Research could be conducted to examine the role of technology in Teaching Factory programs, including the impact of different types of equipment and technologies on student learning outcomes and the potential for the use of emerging technologies such as artificial intelligence and robotics.

The ninth question sought to gather examples of successful Teaching Factory implementations in TVET and to provide valuable information on how the concept could be applied in practice and the expected outcomes. There are many examples of Teaching Factories in Technical and Vocational Education and Training (TVET) programs around the world. Outlined below are a few examples:

Siemens Technical Academy. The Siemens Technical Academy is a Teaching Factory located in Germany that provides training in engineering and technology to students and professionals. The Academy has a range of modern equipment and technologies, and students work on real-world projects under the supervision of qualified instructors. The Siemens Technical Academy (STA) is a teaching factory located in Germany that provides practical training for students and young professionals in a range of technical fields, including electrical engineering, mechatronics, and automation technology. The STA is operated by Siemens AG, a global technology company that provides a wide range of products, services, and solutions in the areas of electrification, automation, and digitalization.

The STA combines theory and practice to provide hands-on training and experience to students and young professionals. It offers a variety of training programs, including apprenticeships, internships, and professional development courses, as well as custom training solutions for companies. The STA also serves as a research and development centre, where students and young professionals can work on real-

world projects and collaborate with Siemens experts to develop innovative solutions (The Siemens Technical Academy, n.d.).

P-TECH. P-TECH (Pathways in Technology Early College High School) is a Teaching Factory program in the United States that provides students with a blend of academic and technical education. Students in the P-TECH program work on real-world projects and have the opportunity to earn college credits and industry certifications. P-TECH schools offer a six-year program that allows students to earn both a high school diploma and an associate's degree in a STEM (science, technology, engineering, and math) field. The Teaching Factory is a space within the school where students can apply the knowledge and skills they have gained in the classroom to real-world problems and projects. These projects are often developed in collaboration with local businesses and industries, and provide students with the opportunity to gain practical experience and learn about potential careers in STEM fields. The P-TECH model was developed by IBM in 2011 and has since been implemented in schools around the United States. It has received widespread support from educators, policymakers, and business leaders for its innovative approach to preparing students for success in college and the workforce (IBM P-TECH, n.d.).

Toyota Technical College. The Toyota Technical College is a Teaching Factory located in Japan that provides training in automotive technology to students and professionals. The College has a range of modern equipment and technologies, and students work on real-world projects under the supervision of qualified instructors. The Toyota Technical College (TTC) is a vocational school located in Toyota City, Aichi Prefecture, Japan. It was founded in 1966 by Toyota Motor Corporation and is operated by the Toyota Motor Corporation Educational Foundation. The college offers a range of technical and vocational education programs, including automotive technology, mechanical engineering, and business management.

One of the key features of the Toyota Technical College is its Teaching Factory, which is a space within the college where students can apply the knowledge and skills they have gained in the classroom to real-world projects and problems. The Teaching Factory provides students with the opportunity to gain practical experience and develop their technical skills through hands-on learning and collaboration with industry partners. The Toyota Technical College is known for its innovative approach to education and its strong partnerships with local businesses and industries. It is recognized as a leader in vocational education in Japan and has received international recognition for its contributions to the development of skilled technical professionals (Toyota Technical School, 2012).

TAFE NSW. TAFE NSW is a Teaching Factory program in Australia that provides vocational education and training in a range of fields, including engineering, manufacturing, and technology. The program has a range of modern equipment and technologies, and students work on real-world projects under the supervision of qualified instructors (TAFE NSW, n.d.).

The benefits and challenges of Teaching Factory examples in TVET programs can vary depending on the specific program and its context. However, some common benefits and challenges can be identified:

Benefits

Hands-on learning. Teaching Factories provide students with practical, hands-on learning experiences that closely resemble the work they will encounter in their future careers. This allows students to develop the technical skills and knowledge they need to succeed in their chosen field.

Real-world relevance. By replicating the real-world environment of a factory, Teaching Factories help students to understand the relevance of their studies and how they can apply their skills in the workplace.

Industry connections. Teaching Factories often have strong connections to industry, which can help to ensure that the training provided is up-to-date and relevant to the needs of employers. This can also provide opportunities for students to network and make connections with potential employers.

Challenges

Cost. Setting up and maintaining a Teaching Factory can be expensive, as it requires the purchase of specialized equipment and technologies, as well as the hiring of qualified instructors. This can be a barrier for some schools or programs that may not have the resources to invest in this type of infrastructure.

Teacher training. In order to be effective, Teaching Factory instructors must have a combination of technical expertise and teaching skills. This can be a challenge, as it can be difficult to find instructors who possess both sets of skills.

Curriculum development. Developing a curriculum that effectively integrates hands-on learning with traditional classroom-based instruction can be challenging, as it requires a thorough understanding of both the technical content and the pedagogy of teaching.

Evaluation. Evaluating the effectiveness of a Teaching Factory program can be challenging, as it requires the development of appropriate assessment tools and methods that accurately measure student learning and progress.

The benefits of Teaching Factory examples in TVET programs often outweigh the challenges, as they provide students with a realistic and relevant learning experience that prepares them for success in their future careers. However, it is important for schools and programs to carefully consider the resources and support needed to effectively implement and maintain a Teaching Factory program.

Conclusions

The Teaching Factory concept in Technical and Vocational Education and Training (TVET) is a pedagogical approach that aims to replicate the real-world environment of a factory within a learning setting. It provides students with practical, hands-on learning experiences that closely resemble the work they will encounter in their future careers and helps them to develop the technical skills and knowledge they need to succeed in their chosen field. Teaching Factories often include a range of modern equipment and technologies and often have strong connections to industry. Despite challenges such as cost and teacher training, the Teaching Factory concept

is widely considered to be an effective approach to vocational education and training, as it provides students with a realistic and relevant learning experience that prepares them for success in their future careers.

Recommendations

There are several potential future directions for the Teaching Factory concept in Technical and Vocational Education and Training (TVET):

1. Increased Use of Technology

As technology continues to advance, Teaching Factories may incorporate more advanced equipment and technologies into their programs. This could include the use of artificial intelligence, robotics, and other emerging technologies, which could help to provide students with even more realistic and relevant learning experiences.

2. Greater Integration with Industry

Teaching Factories may continue to strengthen their connections with industry and work more closely with employers to ensure that the training provided is up-to-date and relevant to the needs of the workforce. This could include the development of industry-specific programs or the incorporation of industry experts into the teaching team.

3. Increased Use of Online and Distance Learning

As more schools and programs adopt online and distance learning platforms, the Teaching Factory concept may be adapted to include these components, allowing students to access training and support remotely. This could be particularly useful for students who live in remote areas or who have other commitments that make it difficult for them to attend in-person classes.

4. Greater Focus on Sustainability

Teaching Factories may place a greater emphasis on sustainability and eco-friendliness in the future, incorporating green technologies and practices into their programs. This could help to prepare students for careers in fields such as renewable energy and sustainable manufacturing.

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