

# Technology Innovation and Transfer in Technical and Vocational Education and Training (TVET) Institutions: Scalability and Sustainability of the Student's Projects

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## **Abstract**

*Technology Innovation and Transfer (TIT) is an engine for the socio-economic growth of any country including Tanzania. TVET has emerged as one of the effective resource growth strategies for the scalability and sustainability of such TIT. One of the ways used by TVET institutions to promote TIT is final year students' projects. However, very little is known about the scalability and sustainability of TIT in the TVET institutions in Tanzania, particularly from the graduates. This paper specifically evaluated the performance of TVET institutions in the technology transfer process (TTP) when considering the final-year students' projects in TVET. Being that the case, this study provides insights into the scalability and sustainability of students' research projects in TVET institutions in Tanzania. The study was approached quantitatively in which data were collected using a questionnaire from 387 TVET graduates who were obtained using multi-stage sampling techniques (simple random, stratified, and convenience). The collected data were analyzed using Descriptive Statistics. The findings reveal that the TTP aspects of invention, invention disclosure, and assessment were well performed. On the other hand, aspects such as protection, marketing, licensing, and financial returns were poorly performed in TVET institutions. Conclusively, there is good performance of scalability and sustainability of the final year students' projects in TVET in invention, invention disclosure, and assessment while poor performance in protection, marketing, licensing, and financial returns. This study calls for excellent performance in all aspects of TTP as far as final-year students' projects are concerned. This will in turn ensure the strong scalability and sustainability of the technology innovation and transfer in TVET.*

**Keywords:** *Technology Innovation, Technology Transfer, Scalability, Sustainability*

## **1.0 INTRODUCTION**

Technology Innovation and Transfer (TIT) is an engine for the socio-economic growth of any country including Tanzania (Tolessa & Singh, 2021). In other words, TIT increases productivity and capacitates the capacity or builds the capacity of different enterprises in the country. Furthermore, TIT increases

competitiveness, adding value, determining long-term survival and bringing changes improvement in dynamics, and creating new things different from the existing ones (Choi & Lim, 2017). In addition, the TIT increases industrial productivity; creates job opportunities, and strong economic development as well as alleviates key societal problems such as climate change and health (Tolessa & Singh, 2021).

Technical and Vocational Education and Training (TVET) has emerged as one of the effective resource growth strategies for the scalability and sustainability of such TIT i.e. TIT is the main ingredient of TVET (Al-Ali, 2021). In other words, TIT to TVET has positive contributions such as updating workshops and laboratories, enhancing research and development, creating effective students' assessment schemes, providing an effective technique for reviewing, updating, and assessing curriculum, enhancing academic staff competencies, ensuring a better learning and teaching environment, and eventually producing a high quality of graduates (Al-Ali, 2021). The TIT allows a free transformation and exchange of technology with local and international industries and businesses through TVET if well utilized (European Commission, 2020; Tolessa & Singh, 2021).

There are different forms and ways used by TVET institutions in promoting TIT. The forms of TIT in TVET include the transfer of technology from the research and development department to other academic departments or interactions and exchange of technology between academic departments (Al-Ali, 2021). For TVET to be an effective resource growth strategy in gaining properly trained or skilled men and modernizing the technological workforce for fast industrialization and national development, the technology transfer process (TTP) is very essential. In other words, TVET is one of the growth strategies for the scalability and sustainability of such TIT (Tolessa & Singh, 2021).

The importance of TIT in TVET has attracted several researchers. For instance, Musyimi (2018) evaluated student trade project designs for recyclability and greening the environment in TVET institutions in the North Rift Region of Kenya. This study shows that the given projects were not environmentally sensitive and did not consider recyclability or disposal after completion. Additionally, the lecturers who supervised the projects did not put any emphasis on environmental sustainability. Furthermore, Moreover, Daub et al. (2020) did a study on university talks and students' walks to describe an innovative approach to integrating sustainability into the structures and processes of a business school without creating resistance. This study reveals which structural elements of the competition have to be adapted according to the needs of sustainable

entrepreneurs. Chikwendu and Amaechi (2021) designed a web-based student project management system to improve the quality, timeliness, and communication in students' final-year projects. The given project automated routine project activities such as listing and selecting project topics, approval of project topics, project report writing guidelines, student/supervisor correspondence, assessment and report submission, and finally report storage and management. Also, Howard et al. (2021) designed research on how successful technological innovations and change processes are sustained and scaled in new learning contexts. The study indicates that research can support the sustainability and scalability of technological innovation projects but has to be balanced with other factors.

In Tanzania specifically, Mtitu (2017) investigated research supervision practices and functional challenges among graduate distant students at the Open University of Tanzania. This study reveals that research supervisors had limited research competence which in turn necessitates research-based training needed in the Open University of Tanzania. Mtebe (2017) further discusses the adoption of educational technologies, such as the Moodle system, to enhance access and improve the quality of education at the University of Dar es Salaam. Elia and Ndenje-Sichalwe (2022) assessed the research pattern of postgraduate students in Library and Information Science (LIS) in Tanzania. The results inform that the most covered research areas included user studies, information industry economics and management, information/learning society, and information technology. The last research areas covered included law, methodology, and information ethics and law. Mkulu (2022) explored the implication of the practice of research innovation in higher learning institutions for quality Education in Mwanza. The exploration shows that the practice of research innovation influences students to be competent in critical thinking, problem-solving, and self-confidence, as well as the provision of autonomy and monetary funds. The study further stresses that research innovation is challenged by low learners' registration, lack of institutional partnership, and monetary capital. Garaba and Kumar (2023) analysed the struggles of students and graduates of TVET in Tanzania. The students and graduates struggle due to the incompetence of TVET teachers and poor perceptions of students, parents, and employers.

Most of the above studies (e.g. Chikwendu, 2021; Howard et al., 2021; Elia & Ndenje-Sichalwe; 2022; Mkulu, 2022; Garaba & Kumar, 2023) addressed TIT. However, most of the given studies did not contextually concentrate on TVET institutions with reference to students' final-year projects but on higher learning institutions (universities). The studies further addressed other aspects of scalability and sustainability on research projects other than aspects technology

Transfer Process (TTP). Therefore, there are scarce studies very little is known about the scalability and sustainability of TIT in the TVET institutions in Tanzania, particularly from the graduates. Therefore, this paper specifically evaluated the performance of TVET institutions in TTP when considering the final year students' projects in TVET.

## **2.0 METHODOLOGY**

### **2.1 Approach of the Study**

This study used a quantitative approach due to the nature of the main objective. Concerning the study objective, the approach had strengths and qualities such as the ability to measure actions, views, attitudes, and draw generalizations from a larger population of surveyed graduates i.e. the approach was good at providing information in a large number of units (Vijayendra, 2023). The approach facilitated the study to obtain objectivity and generalize findings to other situations (Lee, 2006). It also enabled the study to quantify the performance of study variables i.e. scalability and sustainability of students' projects in TVET institutions (Wu & Little, 2011).

### **2.2 Research Design**

This study applied a descriptive cross-sectional survey design as it facilitated studying individual graduates as a unit of analysis. It assisted in covering a large geographical area while measuring the individual graduate's views, attitudes, and characteristics; and it produced an easy way of analyzing the information from the surveyed graduates regarding the scalability and sustainability of the final year students' projects in TVET (Doyle et al., 2020).

### **2.3 Area of the Study**

The area of this study was five cities: Mbeya, Dar es Salaam, Mwanza, Dodoma, and Arusha in Tanzania. The cities are big cities in Tanzania that absorb many graduates. They have numerous zonal headquarters of private and government organizations. They are occupied with businesses and other entrepreneurial enterprises compared to other cities in Tanzania. They have more TVET institutions compared to other towns in Tanzania. Principally, they represent the major zones of Tanzania.

### **2.4 Population and Sampling**

The primary data of this study were collected from TVET graduates. The graduates were used in this study as they are knowledgeable and have experience in the scalability and sustainability of the research projects, and they were directly involved in such projects when they were in their final year in TVET institutions. Also, most of the previous studies (e.g. Chikwendu, 2021; Howard et al., 2021;

Elia & Ndenje-Sichalwe; 2022; Mkulu, 2022; Garaba & Kumar, 2023) used ongoing students, lecturers/instructors, and employers.

The primary data of this study were collected from TVET graduates from different cities in Tanzania. The multi-sampling technique principally was used in this study in which the population was identified purposively, randomly stratified, and eventually conveniently approached for data collection. The purposive sampling technique facilitated to identification of the graduates who were best suited to attend the research objective of this study. In other words, it enabled the identification and selection of information-rich graduates related to the objective of the study at hand. Furthermore, the stratified random sampling techniques were used to stratify the purposively selected graduates into strata of their background information to ensure that almost every case of the TVET is included in the study. Finally, the convenience sampling technique was used to win the graduates who were readily available and willing to participate in the study. The absence of a sampling frame of graduates at the moment of study dictated the use of a convenience sampling technique which allowed to gathering of data that could not have been possible otherwise. Being that case, the convenient sampling technique yielded 387 respondents.

## **2.5 Variables and Measurement**

The main variables of this study are scalability and sustainability. The given variable is operationalized using aspects/steps/stages of the Technology Transfer Process (TTP). These steps are invention/research, invention disclosure, assessment/evaluation, protection, marketing, licensing/product development, and financial returns/commercialization (Princeton University, 2015, University of Toledo, 2023). The statement items regarding the performance of the respective steps in TVET institutions were prepared and tested using a points Likert Scale (1-Poor to 5-Excellent) i.e. *1. Poor, 2. Marginal, 3. Acceptable, 4. Good, 5. Excellent. Accordingly, 1-2 is termed as poor performance (poorly performed), 3-promising performance (promising), and 4-5 is termed as excellent performance (well performed).*

## **2.6 Data Collection**

The primary data of this study were collected principally using the questionnaire. The questionnaire was used as they offered a fast, efficient, and inexpensive means of collecting large amounts of data regarding the scalability and sustainability of the final-year students' projects in TVET.

## **2.7 Validity and Reliability**

The validity and reliability of the used questionnaire were ensured through pre-testing (expert assessments of the items), pilot study, literature review from

which the items were adopted from previous research, ensuring correlation analysis using Pearson Product Moment Correlation Coefficient (r), and Cronbach Alpha Coefficient formula.

## **2.8 Data Analysis**

The collected data were analysed using descriptive statistics. Descriptive statistics was used to quantify and describe the background information of the respondents and their data set in general about the scalability and sustainability of the final year students' projects in TVET. The data analysis was performed by a computer using IBM SPSS Statistics i.e. Version 26. The descriptive statistics results were presented using frequencies and standard percentages.

## **3.0 RESULTS**

This study has only one objective i.e. to evaluate the performance of the technology transfer process (TTP) when considering the final year students' projects in TVET institutions. Before presenting and discussing the results of this objective, this section begins with a presentation of background information of the surveyed respondents (graduates).

### **3.1 Background Information of the Respondents**

#### **3.1.1 Gender of the Respondents**

Both sexes of the graduates were surveyed. In so doing, 60% were male graduates while 40% were female graduates (**Table 1**). The majority of the surveyed graduates were male. This implies that the number of male graduates in TVET institutions is more compared to female graduates in Tanzania.

#### **3.1.2 Age of the Respondents**

Concerning the variable age, the range of ages is from 21 to 40 and above years. The results of the surveyed graduates demonstrate that 19% of the graduates had the age between 21-24 years, 30% between 25-29 years, 37% between 30-34 years, 10% between 35-39 years, and 4% of the graduates had 40 years and above (**Table 1**). The majority of the surveyed graduates were therefore aged between 21 and 34 years old.

#### **3.1.3 Marital Status of the Respondents**

Marital status was one of the background information explored among the surveyed graduates in this study. The results show that 59% of the surveyed graduates were single, 30% married, 6% divorced, and 5% widows (**Table 1**). The majority of the graduates were single. This means that graduates who graduated from TVET institutions from 2018 to 2022 were single in Tanzania.

### **3.1.4 Locations of the Respondents**

Since the area of this study was five cities in Tanzania, the graduates were asked to identify the particular city they were living and working in. In so doing, 18% of the graduates lived/worked in Arusha, 24% lived in Dar es Salaam, 20% lived in Mbeya, 20% lived in Mwanza and 18% of the graduates lived and worked in Dodoma city. The majority of the surveyed graduates were therefore living in Dar es Salaam though minimal difference was noted with reference to other cities.

### **3.1.5 Employment Status of the Respondents**

Furthermore, the results in **Table 1** display that, 25% of the surveyed graduates had no employment, 44% had self-employment and 31% had paid employment. The majority of the graduates had self-employment.

### **3.1.6 Education Level of the Respondents**

The lowest education level considered in this study is the Ordinary Diploma level while the highest level is Postgraduate in either science or engineering. The results in **Table 1 established** that 44% of the surveyed graduates had an Ordinary Diploma level, 56% had a bachelor's degree, and none had a postgraduate level. The majority of the surveyed graduates had bachelor's degrees in Tanzania.

### **3.1.7 Respondents' Year of Graduation**

The study intended to survey graduates from 2017/2018 to 2021/2022. Identifying a particular graduate for his/her year of graduation was very paramount. The results show that 25% graduated in 2017/2018, 28% graduated in 2018/2019, 24% graduated in 2019/2020, 12% graduated in 2020/2021 and 11% graduated in 2021/2022. The majority of surveyed graduates graduated in 2018/2019 though with minimum difference with other years of graduation.

**Table 1: Background Information**

<b>Personal Information</b>	<b>Scale</b>	<b>Frequency</b>	<b>Percent</b>
Sex	1. Male	232	60.0
	2. Female	155	40.0
	<b>Total</b>	<b>387</b>	<b>100.0</b>
Age	1. 21-24 years	74	19.0
	2. 25-29 years	116	30.0
	3. 30-34 years	143	37.0
	4. 35-39 years	39	10.0
	5. 40 and above years	15	4.0
<b>Total</b>	<b>387</b>	<b>100.0</b>	
Marital Status	1. Single	228	59.0
	2. Married	116	30.0
	3. Divorced	24	6.0
	4. Widow	19	5.0
<b>Total</b>	<b>387</b>	<b>100.0</b>	
Residential Area	1. Arusha	72	18.0
	2. Dar es Salaam	93	24.0
	3. Mbeya	77	20.0
	4. Mwanza	76	20.0
	5. Dodoma	69	18.0
<b>Total</b>	<b>500</b>	<b>100.0</b>	
Employment Status	1. No employment	97	25.0
	2. Self-employment	170	44.0
	3. Paid employment	120	31.0
<b>Total</b>	<b>500</b>	<b>100.0</b>	
Education Level	1. Ordinary Diploma	170	44.0
	2. Bachelor Degree	217	56.0
	3. Postgraduate	0	0.0
<b>Total</b>	<b>387</b>	<b>100.0</b>	
Year of Graduation	1. 2017/2018	97	25.0
	2. 2018/2019	108	28.0
	3. 2019/2020	93	24.0
	4. 2020/2021	46	12.0
	5. 2021/2022	43	11.0
<b>Total</b>	<b>387</b>	<b>100.0</b>	



### 3.2 Scalability and Sustainability of the Final Year Students' Projects in TVET

The findings of this study are based on the rating of performance by the surveyed graduates on how the TVET institutions performed in aspects of the technology innovation transfer (TIT) process. In other words, it is based on the rating of the technology transfer process (TTP) when considering the final year students' projects in TVET from the views and opinions of the graduates who were once students and did the projects in their final year in TVET institutions. The TTP included invention, invention disclosure, assessment, protection, marketing, licensing, and financial returns.

In rating the performance of the TTP aspects using the case of students' final year projects, **Table 2** indicates that invention in the TVET institutions in Tanzania had poor performance by 3%, marginal performance by 10%, acceptable performance by 23%, good performance by 56% and excellent performance by 8%. The majority of the surveyed graduates rated invention in students' final year projects as being in good performance in the TVET institutions in Tanzania.

Furthermore, **Table 2** shows that invention disclosure in the TVET institutions in Tanzania had a poor performance of 3%, a marginal performance of 10%, an acceptable performance of 24%, a good performance of 61%, and an excellent performance of 2%. The majority of the surveyed graduates rated invention disclosure in students' final year projects as being in good performance in the TVET institutions in Tanzania.

Additionally, **Table 2** shows that assessment in the TVET institutions in Tanzania had a poor performance of 3%, marginal performance of 7%, acceptable performance of 20%, good performance of 62%, and excellent performance of 8%. The majority of the surveyed graduates rated assessment in students' final year projects as being in good performance in the TVET institutions in Tanzania

On the other hand, **Table 2** shows that protection in the TVET institutions in Tanzania had poor performance by 57%, marginal performance by 24%, acceptable performance by 12%, good performance by 5%, and excellent performance by 2%. The majority of the surveyed graduates rated protection in students' final year projects as being in poor performance in the TVET institutions in Tanzania.

Regarding marketing of the students' final year projects' products, **Table 2** shows that marketing in the TVET institutions in Tanzania had a poor

performance of 60%, marginal performance of 23%, acceptable performance of 10%, good performance of 5%, and excellent performance by 3%. The majority of the surveyed graduates rated marketing in students' final year projects as poor performance in the TVET institutions in Tanzania

Concerning licensing of the student final year projects' products, **Table 2** shows that licensing in the TVET institutions in Tanzania had a poor performance of 64%, marginal performance of 20%, acceptable performance of 11%, good performance of 4%, and excellent performance of 2%. The majority of the surveyed graduates rated licensing in students' final year projects as being in poor performance in the TVET institutions in Tanzania

On the subject of financial returns from the students' final year projects' products, **Table 2** shows that financial returns in the TVET institutions in Tanzania had poor performance by 57%, marginal performance by 22%, acceptable performance by 9%, good performance by 7% and excellent performance by 5%. The majority of the surveyed graduates rated financial returns in students' final year projects as being in poor performance in the TVET institutions in Tanzania.

**Table 2: Scalability and Sustainability of the Final Year Students' Projects in TVET**

Rating Scale	Invention		Invention Disclosure		Assessment		Protection		Marketing		Licensing		Financial Returns	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Poor	10	3.0	13	3.0	11	3.0	219	<b>57.0</b>	231	<b>60.0</b>	247	<b>64.0</b>	222	<b>57.0</b>
Marginal	40	10.0	39	10.0	27	7.0	93	24.0	89	23.0	78	20.0	85	22.0
Acceptable	89	23.0	91	24.0	77	20.0	45	12.0	37	10.0	41	11.0	33	9.0
Good	218	<b>56.0</b>	237	<b>61.0</b>	241	<b>62.0</b>	21	5.0	18	5.0	15	4.0	27	7.0
Excellent	30	8.0	7	2.0	31	8.0	9	2.0	12	3.0	06	2.0	20	5.0
<b>Total</b>	<b>387</b>	<b>100.0</b>	<b>387</b>	<b>100.0</b>	<b>387</b>	<b>100.0</b>	<b>387</b>	<b>100.0</b>	<b>387</b>	<b>100.0</b>	<b>387</b>	<b>100.0</b>	<b>387</b>	<b>100.0</b>

#### 4.0 DISCUSSION OF THE FINDINGS

The results from section four above generally indicate that there is a good performance of scalability and sustainability of the final year students' project in TVET institutions in aspects such as invention, invention disclosure, and assessment. These results imply that the technology innovation transfer through final year students' projects in TVET institutions is performing well when considering stages such as invention, disclosure, and assessment. Each step is discussed below in detail:

Regarding invention/research, the TVET institutions were performing well in which final year students are facilitated in conceiving an invention,

communicating the invention with the institution authority through the supervisor, maintaining detailed records on the invention development, seeking advice and resources needed from the institution authority. Concerning disclosure, the TVET institutions were also performing well as the final year students are assisted in formally disclosing their inventions to the institution authority through an invention report form, clearly describing the innovation, commercial application, and who is involved and getting educated on the critical information provided for improvement. In assessment, the final year students' projects in TVET institutions are evaluated to determine their marketability and patentability, discussed with other experts, make recommendations for further steps of the technology transfer process, recording the pertinent information of the technology in the database, and get informed of the improvements (if any) required.

On the other hand, the results in the previous section portray that there is poor performance of scalability and sustainability of the final year students' projects in TVET institutions in aspects such as protection, marketing, licensing, and financial returns. These results imply that the technology innovation transfer through final year students' projects in TVET institutions is performing **poorly** when considering stages such as protection, marketing, licensing, and financial returns. Each step is discussed below in detail:

Regarding protection, the TVET institutions were performing poorly in which final year students are not facilitated in obtaining the protection of the technology i.e. the TVET had very little or no efforts in making the protection of the students' invention for attracting potential interest of the commercial partners. Concerning marketing, the TVET institutions had very little or no effort in marketing the available technologies of the students' projects in attracting licensing opportunities or even initiating the technology for research material that is not patentable but still offers some commercial value if improved. In licensing, the TVET institutions had very little or no effort in securing rights to the technology from the students' projects, particularly to the potential companies. The license is aimed at giving the owners of the technology-TVET institutions and students another party (i.e. potential companies) to produce, use, or sell hand in hand clear identification of the rights, responsibilities, exclusivity, and agreement terms. Regarding financial returns/commercialization, the TVET institutions are not doing well in facilitating students in post-license compliance aimed at maintaining the scheduled development of the agreed technology, payment of royalties, and compliance with the agreed conditions of the earlier license.

The results of this study on the performance of scalability and sustainability of the final year students' projects in TVET institutions are likewise supported by previous studies (e.g. Chikwendu, 2021; Howard et al., 2021; Elia & Ndenje-Sichalwe; 2022; Mkulu, 2022; Garaba & Kumar, 2023). The given studies have addressed the TIT in terms of projects of project designs and they have shown that the TIT is performing well or poorly in some steps of the technology transfer process as found in the study at hand.

## **5.0 CONCLUSION AND RECOMMENDATION**

This study generally aimed at evaluating the performance of TVET institutions in the technology transfer process (TTP) when taking into account the final year students' projects in TVET institutions. It is generally concluded that there was a good performance of scalability and sustainability of the final year students' project in TVET institutions in some aspects (i.e. invention, invention disclosure, and assessment) while there was poor performance in some aspects (i.e. protection, marketing, licensing, and financial returns) of scalability and sustainability of the final year students project in TVET institutions.

This study has been able to contribute to clearly showing the performance of TTP as far as aspects of TTP are concerned in the final year students' projects in TVET institutions. It has as well the policy implications, particularly for TVET policymakers. This means that this becomes important input on the areas and aspects of TIT to be improved, reviewing and improving the existing policies accordingly, and allocating more resources for strengthening the TTP process.

This study has not been able to establish reasons for good or poor performance in some aspects of the TTP but can be considered as an area for further research. Finally, the poor performance of the TTP aspects in final year students' projects of the TVET institutions call for both private and public investment for improvement and assurance of the strong scalability and sustainability of the technology innovation and transfer in TVET at large.

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