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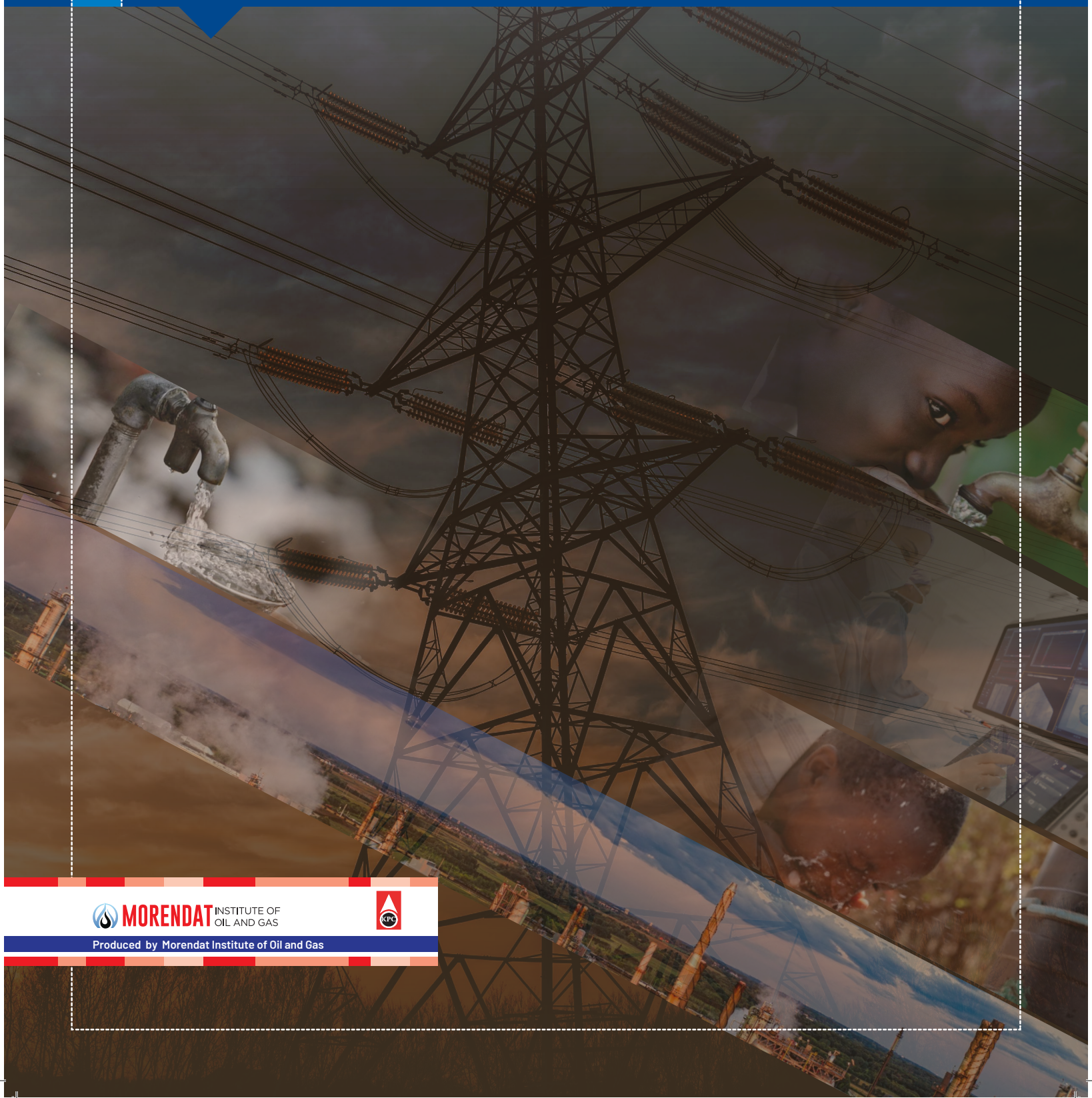

MORENDAT INSTITUTE OF OIL AND GAS

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The African Journal of Energy, Engineering and Training (AJEET) is a peer reviewed journal published by the Morendat Institute of Oil and gas. Morendat Institute of Oil & Gas (MIOG) offers training in oil & gas related courses. It was set up following a heads of state summit consisting of Presidents of Kenya, Uganda, Rwanda and South Sudan during the 3rd Heads of State Summit held in Kigali, Rwanda, on October 28, 2013.

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1. Build human resource capacity in the member states to manage, operate and maintain Oil & Gas Pipelines.
2. Harness internal knowledge and develop new skills required by KPC to implement the Corporate Strategic Plan – Vision 2025.
3. Conduct Research and offer consultancy services in various technical fields in Oil & Gas Pipelines.
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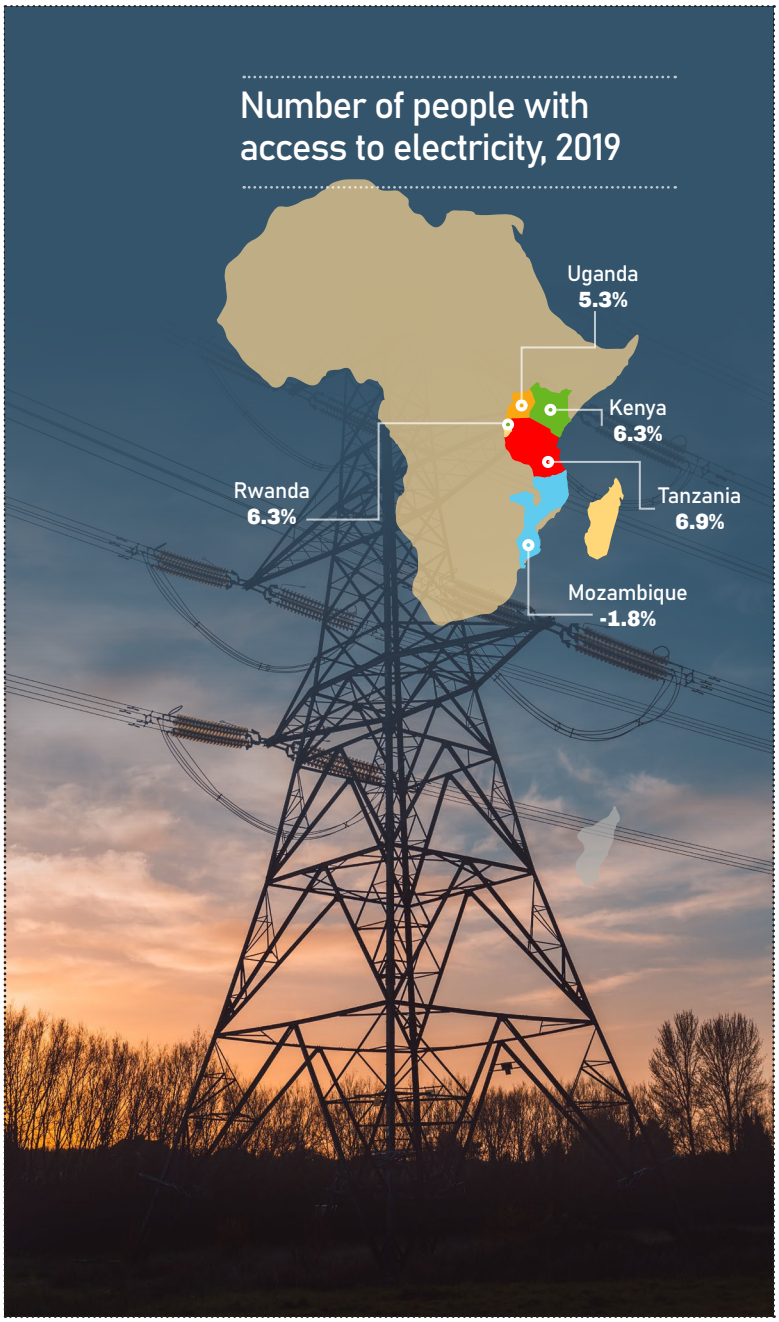

AFRICAN JOURNAL OF ENERGY, ENGINEERING AND TRAINING A JOURNAL OF MORENDAT INSTITUTE OF OIL AND GAS

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Message from the Chief Editor

I am delighted to present to you the inaugural issue of the African Journal of Energy, Engineering, and Training. It is with great pleasure and enthusiasm that we bring forth this publication, dedicated to exploring and advancing the realms of energy, engineering, and training in the African context. Africa stands at a pivotal juncture in its journey towards sustainable development, and the fields of energy, engineering, and training play vital roles in shaping its future. This journal aims to be a platform where researchers, practitioners, educators, and policymakers can come together to share their knowledge, expertise, and experiences in these crucial areas. Our vision for the African Journal of Energy, Engineering, and Training is to foster innovation, facilitate collaboration, and contribute to the transformation of the energy landscape on the continent. Through the dissemination of high-quality research, insightful analyses, and thought-provoking perspectives, we strive to catalyze positive change and drive sustainable development across Africa. In each issue, you can expect a diverse range of articles covering various aspects of energy generation, distribution, and management, cutting-edge engineering solutions, and effective training methodologies. Our goal is to provide a comprehensive and multidisciplinary approach, encompassing all aspects of the energy sector, from renewable energy technologies and infrastructure development to policy frameworks and capacity building initiatives. As the Chief Editor, I am privileged to work alongside a dedicated team of experts who have generously contributed their time and expertise to ensure the quality and relevance of the content presented in this journal. I would like to extend my sincere gratitude to all the authors, reviewers, and editorial board members who have played a pivotal role in making this vision a reality. I invite you to explore the articles in this first issue and engage with the ideas, innovations, and research presented herein. It is my hope that the African Journal of Energy, Engineering, and Training will serve as a catalyst for collaboration and knowledge exchange, fostering a vibrant community of researchers, practitioners, and policymakers dedicated to advancing energy solutions, engineering excellence, and transformative training practices in Africa.

We are excited to embark on this journey with you, and we eagerly await your contributions, feedback, and support as we strive to make a meaningful impact on the energy landscape of Africa. Thank you for joining us on this remarkable endeavor.

Prof. Kisilu M. Kitainge

Chief Editor
African Journal of Energy, Engineering and Training

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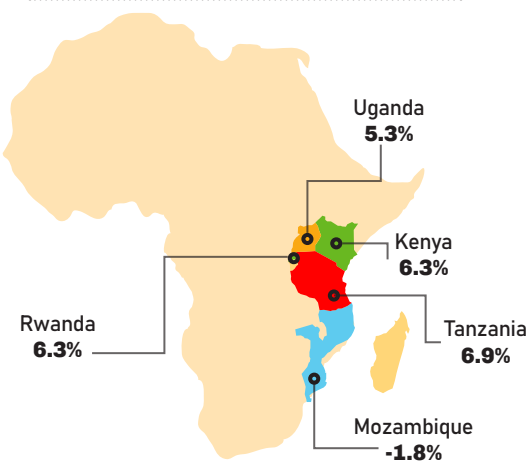

Advancing United Nations SDG7 Through Adaptation Of Liquefied Natural Gas

ABSTRACT

The seventh sustainable development goal aims to ensure universal access to affordable, reliable, sustainable and modern energy services by 2030. One of the resolutions during the Conference of Parties 26(COP26) held in Glasgow Scotland in 2021 on energy was transition to clean energy use. The Forests, Agriculture and Commodity Trade (FACT) Dialogue, a road map for the sustainable development and trade of agriculture commodities was launched. This means that there is a need to reconsider further sources of energy especially for household cooking and heating. China, Japan, South Korea and India are the world's leading importers of LNG. Despite the fact that they do not have any reserves of LNG, they are among the highest consumers of LNG in the world. For example, leading LNG importing company in the world, KOGAS of South Korea also has the largest storage capacity. 84% of household energy use in S. Korea is from LNG piped directly to homes. Tanzania is a sleeping giant as far as LNG is concerned. It has 57.54T of LNG both offshore and onshore yet it is estimated that more than 95% of households in Tanzania use firewood and charcoal as their source of energy for cooking and with electricity access at only 39.9%. Tanzania's estimated natural gas reserves, are enough to cover the country's domestic use and make Tanzania the next natural gas hub in Africa. The natural gas from Songo Songo was first commercialized in 2004 and the gas from Mnazi Bay in 2006. The commercialization of the two discoveries propelled further gas exploration in Tanzania both onshore and offshore. Investments efforts by the government are geared towards propelling Tanzania to the club of Liquefied Natural Gas (LNG) exporters. Russia's invasion of Ukraine has further accelerated this move considering that nations worldwide more so Europe have shifted focus to looking for new energy sources. For East Africa there is a proposal for Tanzania – Uganda pipeline 1,800kM; Tanzania – Kenya pipeline of 600kM from Mtwara to Mombasa, an MOU between the two countries has been signed.

Coal (anthracite)	228.6
Coal (bituminous)	205.7
Coal (lignite)	215.4
Coal (subbituminous)	214.3
Diesel fuel and heating oil (HFO)	161.3
Gasoline (without ethanol)	157.2
Propane	139.0
Natural gas	117.0

Key words: Natural gas, seventh sustainable development goal, clean energy, carbon emissions.

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1.0 INTRODUCTION

Tanzania and the world at large have a number of international protocols that are driving them towards adoption of clean, safe and sustainable energy. The seventh Sustainable Development Goal aims to ensure access to affordable, reliable, sustainable and modern energy for all by 2030. One of the resolutions during the Conference of Parties 26 (COP26) held in Glasgow Scotland in 2021 on energy was transition to clean energy use. During this conference, 100 nations expressed that they intend to end sale of internal combustion engines in leading markets by the year 2035. Additionally, they purpose to end the sale of the engines worldwide by 2040 so as to progress towards the decarbonization process.

According to the National Census of 2012, about 70% of Tanzanians reside in rural areas. Whereas 69.8% of the urban Tanzanian population had access to electricity, in rural areas, households connected to electricity accounted for 24.5% in 2019/20 compared to 16.9% in 2016/17. Therefore, the Government of Tanzania plans to increase rural connection levels to 50% by 2025 and at least 75% by 2033. A point to note is that S. Korea does not have any Liquified Natural Gas (LNG) reserves, yet it has the biggest LNG storage facility in the world. It has 77 storage tanks with a total capacity of 12.16million kl. 84% of household energy use is from LNG which is piped to the homes through pipeline networks with total length of 5,027km. Moreover, 25% of the electricity production comes from natural gas.

2.0 LIQUIFIED NATURAL GAS

Liquefied Natural Gas is a natural gas that has been cooled to a liquid state, at about -162° centigrade , for shipping and storage. The volume of natural gas in its liquid state is about 600 times smaller than its volume in its gaseous state. In short, natural gas is converted into LNG for the main purpose of transporting large energy from natural gas in a containment (in liquid state) that is relatively smaller compared to when would have been transported in its gaseous state. LNG is purely composed of natural gas which is mainly methane. LNG is considered to be environmentally friendly due to its low carbon emission as compared to other fossil fuels. Natural gas, coal, diesel fuels emit different amounts of carbon dioxide. According to the U.S. Energy Information Administration, natural gas emits approximately 50% less CO2 than coal. Likewise, different types of coal produce different amounts of CO2 while burning are Illustrated in table 1.

Table 1: Pounds of CO2 emitted per million British thermal units (Btu) of energy for various fuels:

Source: www.eia.gov

3.0 NATURAL GAS RESERVES, PRODUCTION AND CONSUMPTION

3.1 Worldmeter

Natural gas is one of the mainstays of global energy. Worldwide consumption is rising rapidly and in 2018 gas accounted for almost half of the growth in total global energy demand. Gas plays many different roles in the energy sector and, where it replaces more polluting fuels, it also reduces air pollution and limits emissions of carbon dioxide. A report from the IEA's World Energy Outlook team provides an evidence base for this important discussion. It finds that switching to natural gas has already helped to limit the rise in global emissions since 2010, alongside the deployment of renewables and nuclear energy and improvements in energy efficiency (Birol, 2022).

The report further shows that the contribution of gas to energy transitions varies widely across regions, between sectors and over time. Table 2 gives information on global position of world reserves, percentage world share, export and consumption positions.

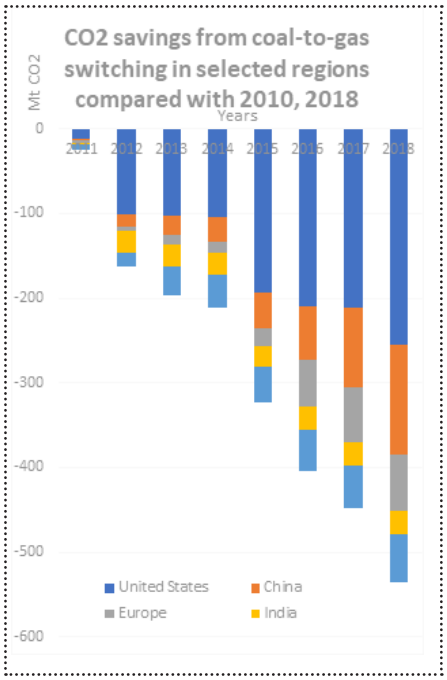
Table 2: List of countries by natural gas reserves, export and consumption

Country	Leading gas reserve		Position as exporter	Position as consumer
	Position	% world share		
Russia	1	24.3	1	2
Iran	2	17.3	16	4
Qatar	3	12.5	3	22
United State	4	5.3	2	1
Saudi Arabia	5	4.2	None	7
Unite Arab Emirate	7	3.1	25	10
Nigeria	9	2.6	10	38
China	10	2.4	28	3
Algeria	11	2.3	9	26
Tanzania	82	0.003	None	91
Mozambique	14	1.4	None	82

The contribution of gas to energy transitions varies widely across regions, between sectors and over time. Gas cannot, of course, do it all to bring down environmental emissions.

According to BiroL (2022), the four countries and regions chosen for in-depth analysis in the report – the United States, Europe, China and India – display a wide range of market and policy dynamics, which affects the ways in which coal and gas compete. In the United States, the shale revolution has had a dramatic effect on gas supply and prices. Alongside some state-level as well as federal-level environmental policies this has pushed gas into the energy mix while pushing out coal. Since 2010, the market share of gas has increased more than any other energy source. In China, gas demand has risen very quickly in recent years because of a major policy push to improve air quality. There has been relatively less switching in Europe since 2010, with the notable exception of the United Kingdom. However, today's combination of low gas prices and higher CO2 prices in the European Union is giving this process renewed momentum. In India, gas currently has a small share of the energy mix. Large-scale switching has been held back by supply constraints and affordability issues, as well as a lack of infrastructure. Figure 1 shows the role of gas in today's eenergy transitions (IEA, 2019).

Figure 1:The Role of Gas in Today's Energy Transitions | IEA 2019. All rights reserved.



Gas prices - The shale revolution in the United States has in general brought down gas prices, and the growth of destination-flexible, hub-priced LNG exports from the United States is providing a catalyst for a more liquid global gas market. However, even though global gas markets are becoming more interconnected, there is still no global gas price. The lower energy density of gas compared to oil or coal means that transportation by pipeline or as LNG takes a relatively high share of the delivered cost, making geographical proximity to resource-rich areas an important determining factor for affordability.

3.2 Africa meter

Africa is a continent richly endowed with natural resources with almost half of its 55 countries known to have proven natural gas reserves. Across the entire continent, natural gas reserves amount to a total of more than 800 trillion cubic feet, with BP predicting that the production of natural gas in the continent will expand by 80% by 2035, contributing to rising Gross Domestic Profit (GDP), the emergence of middle-class consumers and increased market value. As a major source of wealth and energy in Africa, the development of oil and gas resources proves critical for economic growth and revenue expansion. The following list comprises the Top Ten Natural Gas Reserves in Africa by country:

Table 2: Top 10 African Countries Sitting on the Most Natural Gas

Position	Country	Reserves in TCF	Position as exporter
1	Nigeria	206.53	10
2	Algeria	159.1	9
3	Senegal	120	none
4	Mozambique	100	none
5	Egypt	77.2	27
6	Tanzania	57.54	None
7	Libya	53.1	30
8	Angola	13.5	none
9	Congo	10.1	none
10	Equatorial Guinea	5	Exports*

Source: Energy Capital Power, 2021 (TCF – Trillion Cubic Feet)

*** Export position not stated**

Gas prices - Transportation of natural gas by pipeline or as LNG takes a relatively high share of the delivered cost, making geographical proximity to resource-rich areas an important determining factor for affordability. African countries should take advantage of availability of the large NG in the continent to implement SDG7. More so the countries with the reserves.

4.0 ENERGY USE IN EAST AFRICA

4.1Access to electricity

Electricity is considered as one of the main source of clean energy especially if produced from renewable energy or NG. Access to electricity is fairly low in East Africa compared to the world. Figures 2 and 3 illustrates the share of electricity in East Africa with Mozambique included because of its large reserves of NG and proximity to EA. Share of the population with access to electricity – TZ is presented in Figures 4 and 5. Figure 6. Illustrates Percentage of the population that has access to clean energy in EA Incl. Mozambique.

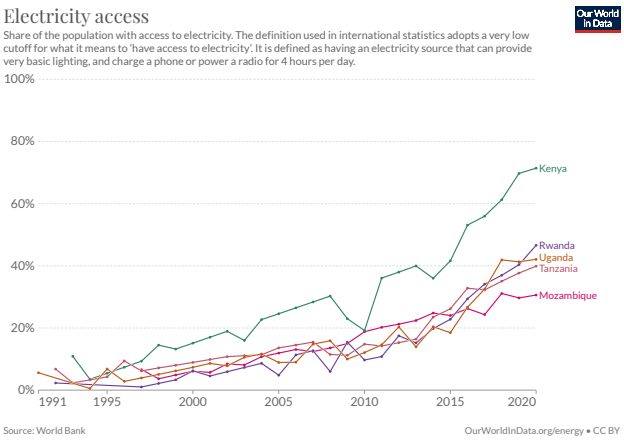


Figure 2: Share of population with access to electricity in EA, Mozambique incl

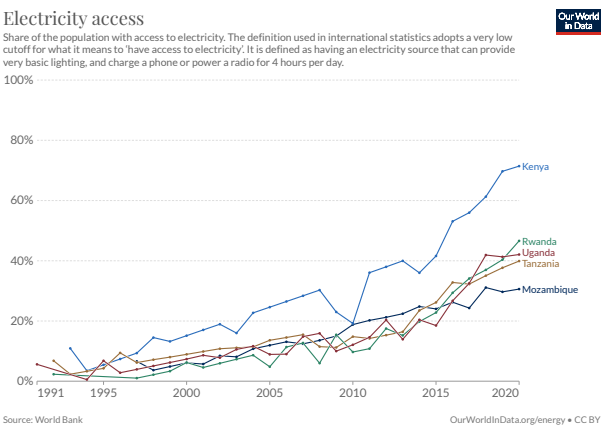


Figure 3: Share of population with access to electricity in EA, Mozambique incl. with percentages

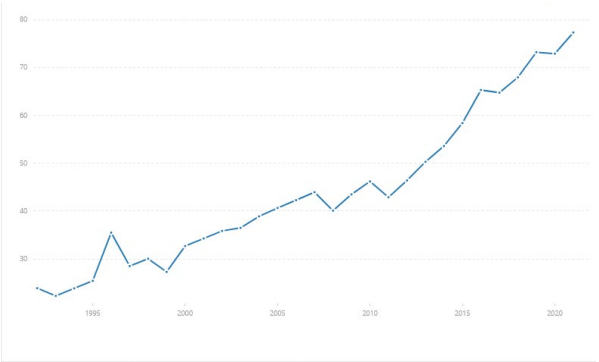


Figure 4: Percentage urban population with access to electricity in Tanzania

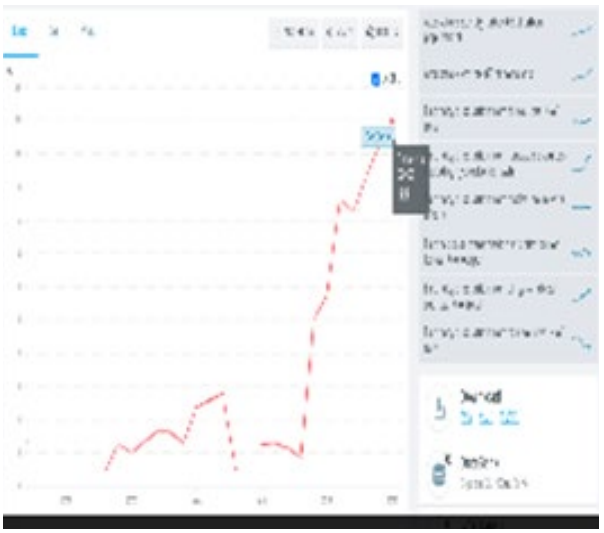


Figure 5: Percentage of rural population with access to electricity in Tanzania

4.2 Access to clean energy

The graph below indicates share of the population with access to clean energy for cooking in East Africa incl. Mozambique

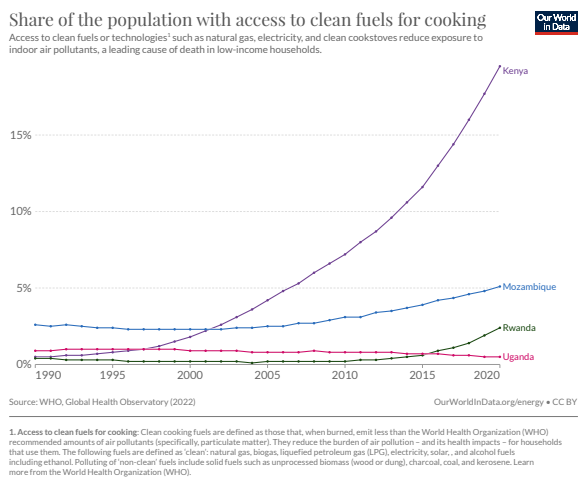
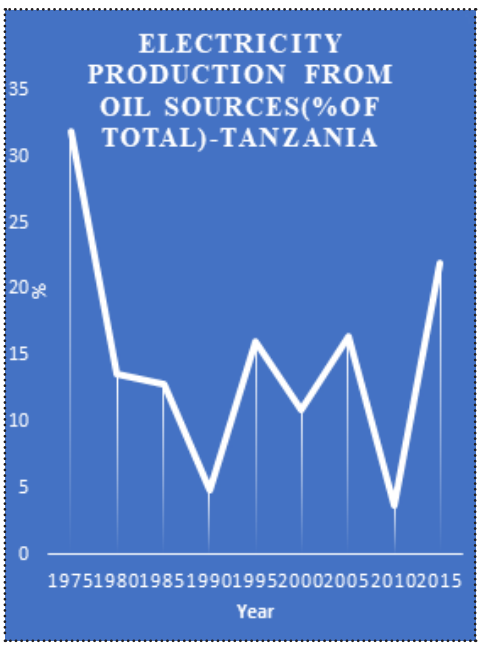


Figure 6: Percentage population access to clean energy in EA Incl. Mozambique

4.3 Sources of electricity production in Tanzania

The graph below shows the trend in electricity production in Tanzania using heavy fuel oil.
It is encouraging to note that electricity generation in Tanzania using HFO has drastically reduced over the years from 1975 to date. Although the graph is indicative upto 2015. A comparison of Figure 7, with Figure 8 shows what necessitated the reduction. With reduction in the use of HFO, the use of natural gas in electricity production has gone up. Eventually becoming the leading fuel in electricity production in Tanzania.



Source: www.databank.org/indicator/EG.ELC.FOSL.ZS/Tz

Figure7: Electricity production from oil sources (% of total)

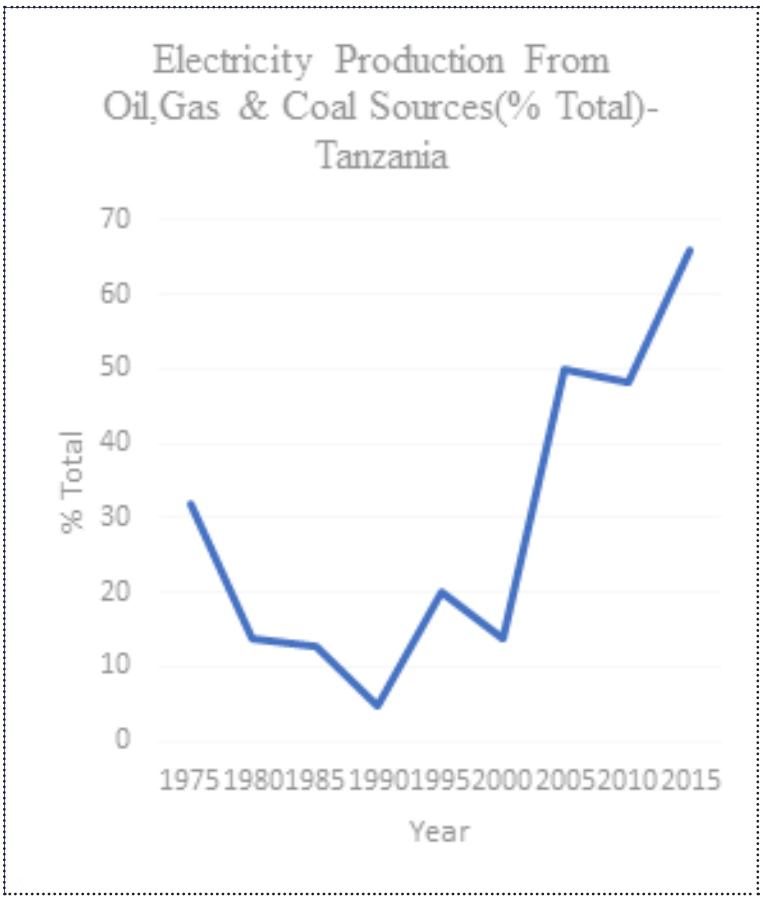


Figure 8: Electricity production from oil and gas sources

5.0 TANZANIA'S OPPORTUNITIES FOR LNG INVESTMENTS

5.1 Vast NG reserves at the coastal area both onshore and offshore

Tanzania's exploration for natural gas has taken more than 50 years with the first natural gas discovery made in 1974 on the Songo Songo Island (Lindi Region). The second discovery at the Mnazi Bay (Mtwara Region) in 1982. Natural gas was discovered both offshore and onshore at the Songo Songo Island, while the gas discovery at Mnazi Bay was only offshore. It's estimated that the total available gas is 57 trillion cubic feet with a total annual production of 110 billion cubic feet from three fields: Songo Songo, Mnazi Bay, and Kiliwani North.) Natural gas from Songo Songo was first commercialized in 2004 and the gas from Mnazi Bay was commercialized in 2006. The commercialization of the two discoveries propelled further gas exploration in Tanzania both onshore and offshore.

Investments efforts by the government are geared towards propelling Tanzania to the club of LNG exporters. Russia's invasion of Ukraine has further accelerated this move considering that nations worldwide, more so Europe, have shifted focus to looking for new energy sources. Therefore, Tanzania investments in LNG projects could reach $40 billion. The strategy is to have shipment of LNG gas by the year 2030. This will be made possible by

negotiating for financing and technical support from foreign oil and gas companies.

In March 2020, the Kenya and Tanzania governments agreed to construct a 600 km Pipeline from Songo Songo Island to Mombasa at a cost of $1.1billion. At present it is envisaged to transport natural gas from Mtwara through Tanga (Tanzania) to Mombasa (Kenya). This is a more convenient means of transport due to its distance and the route is relatively cheap compared to other routes. The Tz/Ke gas pipeline deal is still at its infancy stage where members of Joint Technical Committee and Steering Committee have been appointed from both countries. If the Tz-Ke pipeline picks up, this will be the first NG export Tanzania will realize.

5.2 Vast NG reserves in the neighboring country of Mozambique

Mozambique holds roughly 100 trillion cubic feet of proven natural gas reserves, accounting for approximately 1% of the world's total. The country's proven gas reserves are able to meet 1,545.7 times its annual consumption, meaning the southern-African country has 1,500 years of gas left. Once the uptake infrastructure is in place, Tanzania ought to take advantage of that and link up to Mozambique with a view of becoming NG hub in East and Central Africa.

CONCLUSION

Tanzania and Mozambique – home to East Africa's largest natural gas reserves and with a combined capacity of nearly 157 trillion cubic feet (TCF) – must quicken their pace as the race for supply contracts accelerates. East Africa benefits from convenient geography, with the coastline acting as a springboard to market to rising demand in the Middle East, India, China, Southeast Asia and Northern Europe.

As earlier stated, transportation of NG by pipeline or as LNG takes a relatively high share of the delivered cost, making geographical proximity to resource-rich areas an important determining factor for affordability. Africa and East Africa in particular should take advantage of the vast NG reserves in Tanzania and Mozambique to make LNG their main source of fuel mainly in industry and domestic use as well as electricity production in the place of fossil fuel. This will see the region realize SDG7. To the benefit of the health of their populations as well as adaption of clean energy use towards de-carbonization.

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The Effects Of Laboratory Method On Mathematics Performance Among Secondary School Students In Kapseret Sub County, Kenya

The Effects Of Laboratory Method On Mathematics Performance Among Secondary School Students In Kapseret Sub County, Kenya

ABSTRACT

Mathematics is compulsory for all learners in secondary schools as recommended by the Kenya Institute of Curriculum Development, 2010. The performance of mathematics has been consistently low and one of the reasons is due to lack of Mathematics laboratory. The study sought to determine Mathematics performance among secondary school's students. The study instruments that were used included pre-test, post-test non-equivalent group experimental design, questionnaires and interview schedule. The researcher sampled 298 students and 26 teachers who took part in the study. The Form two students were selected to participate in the study. A sample size that represented the study population was selected using simple random sampling and purposive sampling while stratified sampling was used to select the schools. The study used the Solomon Four-Group design where two groups were formed, one experimental and one control group. The experimental group entered laboratory instructional strategy method while the control group entered conventional instructional strategy method. The respondents were assigned in their complete classes to four groups; experimental groups 1 and 3, and control groups 2 and 4. All the groups were taught the same content of the reflection and congruence. However, groups 1 and 3 were taught using laboratory method while groups 2 and 4 were taught by conventional methods. Groups 1 and 3 were pre-tested prior to the implementation of the laboratory method treatment. Teachers who took part in the study were inducted prior to the study by the researcher for period of three weeks. Mathematics Achievement Test 1 and Mathematics Achievement Test 2, questionnaires and interviews were used to collect data. SPSS were used to aid in data analysis. Chi-square tests were used to establish relationships. The study findings indicated that the laboratory method arouses the learners' interest, increased learner participation, boosted on the performance, enabled learners to develop the necessary skills for more advanced study research and promoted the development of scientific thinking. The study recommends that there is need for teachers to use laboratory method which ensures that learners are involved and engaged more in doing Mathematics activities and teachers have to be trained on the use of the laboratory method.

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Key words: Mathematics, Laboratory method, Conventional method, Quasi experimental, Solomon Four-Group, Pre-test, Post-test

Introduction

Globally, Mathematics is regarded as core subjects in the school curriculum (Suleiman & Hammed, 2019). A nation's socioeconomic development is greatly influenced by its basis in scientific and technological knowledge (Chand et al., 2021). According to a study by Sa'ad et al. (2014), without a solid understanding of Mathematics, neither education nor daily living can run well. However, poor arithmetic performance has emerged as a persistent issue that could hinder these developing nations from attaining their developmental objectives (Mabena et al., 2021).

For careers in the sciences, such as engineering, pharmacology, environmental science, and technology, mathematics study is a necessity for secondary education in Kenya. Mathematics, according to Maass et al. (2019), is the foundation of science and technology and

performs several roles that are crucial to the operation of every field of the scientific and technical community. It is a subject, by Asad et al. (2020) and Nkirote & Thinguri (2020) that enables a Learner to have an appropriate understanding and interpretation of general scientific and technological principles, which leads to technology. The importance of Mathematics in science, technology, and invention (STI) has been widely recognized by the Kenyan government through the 2030 vision (Daniels, 2017).

Despite the highly applauded and acknowledged significance of Mathematics and the fact that it is a prerequisite for the majority of subjects, poor achievement and lack of interest in Mathematics (and STEM) among students continue to be a problem in both developed and developing countries' schools, colleges, and universities (Sharma et al., 2018; 2019). According to students' perceptions of the topic in schools, Mathematics is still one of the most difficult (Brown et al., 2020). Both internal exams and the Kenya Certificate of Secondary Education have often shown poor math performance (Ochieng et al., 2017). According to KNEC (2021), math scores have historically lagged behind those in other science courses. Students routinely do poorly on internal and external Mathematics assessments, according to Desoete et al. (2019), Eyong et al. (2020), and Njoroge (2022).

There are numerous explanations for why students perform poorly in Mathematics classes. Researchers have identified several factors that contribute to poor academic performance in Mathematics, including student attitudes toward the subject, a lack of teaching experience, the state of the economy, the use of ineffective teaching strategies, and teacher and student attitudes (VaraidzaiMakondo & Makondo, 2020). Faith (2020) a different researcher, identified several factors that contribute to subpar Mathematics achievement, including insufficient teaching staff, student absenteeism, low entry scores, subpar assessment systems, and subpar teaching methods. Students' low performance in math classes is the result of a lack of practical applications and insufficient skill and knowledge acquisition, which demotivates them from pursuing further study in the field (Lave, 2021). The researcher has noted that Kapseret Sub-county has not been spared to this national predicament.

Table 1.1 represents the Kapseret Sub-County KCSE performance for the past years (2017-2021).

Table 1.1: Kapseret Sub-County KCSE performance for the past years (2017-2021)

Year	Very good	Good	Average	Poor	Entry	Mean Score	Grade
2018		106	284	1109	1625	3.60	D+
2019	157	173	350	1367	2047	3.67	D+
2020	161	206	386	1409	2147	3.37	D
2021	72	128	222	1101	1523	3.25	D

(Source: SCDE, 2021)

Proper solutions to improve learner performance in mathematics depend on knowing the causes of poor performance in the subject. One of the solutions to avert poor performance of mathematics is to change instruction methods. Recently, laboratory method has been proposed to aid mathematics performance as opposed to conventional method. Laboratory method refers to that method in which students learn Mathematics by carrying out mathematical practical's in a Mathematics room/ laboratory. The laboratory is highly helpful in subjects like Biology, Chemistry, and Physics since it allows students to engage in practical activity, which inspires them to learn more (Affeldt et al., 2017). According to Njoroge (2022) problem-solving methods, such as using a laboratory to teach and learn chemistry, can help students improve their ability to communicate, work in a team, and access and utilize knowledge. Mathematics laboratory instruction can help students create concepts through experience with physical things (Okeke & Okigbo, 2021).

In Kenyan secondary schools, where there are no Mathematics laboratories, the laboratory method is not used to teach Mathematics; rather, it is only taken into consideration for other Science subjects, which is one of the reasons for low achievement in Mathematics (Okeke & Okigbo, 2021). Therefore, the use of such teaching techniques in Mathematics instruction is necessary to raise student achievement.

Methodology

Study Area

The study was conducted in Kapseret Sub County in Uasin Gishu County. Kapseret Sub-County has five wards and estimated surface area of about 451 square kilometers and approximately 121,178 individuals (Kenyacradle.com). It has County has approximately 26 secondary school.

Figure 1.1: A map of the study area in Kenya

Research Design

Solomon's Four Group Design was used in the study's experimental procedures. This is due to the fact that secondary school classes that have already been formed continue to exist as complete units and that school authorities do not let such classes to be disbanded and reconstituted for study (Akhtar, 2016). The chosen schools were divided into intact groups and randomly assigned to the treatment and control conditions.

Table 1.2: Solomon four groups

Group	Pre test	Treatment	Post test
Experimental 1	Yes	Lab Method	Yes
Experimental 2	No	Lab Method	Yes
Control 1	Yes	Conventional Method	Yes
Control 2	No	Conventional Method	Yes

Target Population, Sample Size and Sampling Techniques

The target population comprised of all the form two's students where topic on Reflection and Congruence is taught. The students are important because they provided evidence of laboratory methods enhancing good performance among students when compared to conventional methods. The respondents were selected using stratified random sampling, simple random sampling and purposive sampling. The schools were first stratified (extra county, county and private secondary) then simple randomly selected to take part in the study within a strata. The researcher sampled 20 schools out of the possible 26 secondary schools within the sub-county, 10 schools were used as control and 10 experimental. The students were sampled using simple random method; 298 were selected to take part in the study. Teachers were sampled using purposive sampling method and total of 26 teachers took part in the study. The students were distributed in control 1 & 2 and experiment 1 & 2. The total sampled respondents were 324 individuals.

Research Instruments

Mathematics Achievement Test 1 and Mathematics Achievement Test 2, questionnaire and interview schedule were used to collect data on the use of laboratory method on Mathematics performance.

Data Analysis

Data collected was analyzed with the help of Statistical Package for Social Science (SPSS) software (version 21). Data collected through questionnaires was coded, analyzed and relationships between variables derived using cross-tabulation. Descriptive statistics were used to determine frequencies and percentages while inferential statistical analysis using the chi-square test was used to determine whether expected frequencies differ from the actual frequencies.

Results

Two hundred and ninety eighth learners participated in this research study. In terms of gender male 154 (51.92%) and female 144 (48.08%) learners had almost equal proportion hence very low gender disparity. Twenty six teachers of Mathematics took part in the study; there were 14 (53.85%) females and 12 (46.15%) males.

Table 1.3: Demographic characteristics

Respondents	Sampled	Participated	Percentage respondent
Teachers	26	26	100%
Students	900	298	33%

Effects of laboratory method on Mathematics performance

The experiment was done by inducted teachers. All the teachers who participated in the study were inducted by the researcher, who then helped in monitoring of the teaching. The study took a whole month. The selected schools were both boarding and day school; to avoid contamination the student on experimental were caution on sharing of the information with those of control. During the study both conventional method and laboratory methods were used. The students were assumed to have the same capabilities to solve and understand the Mathematics. The post-test finding indicated the experimental students' performance was higher than control that used the conventional method. The laboratory method helped students retain the learned concept longer ($p<0.05$), understand the concept better than before ($p<0.05$), removing abstractness ($p<0.05$), boosted the performance ($p<0.05$), increased effective teaching and learning ($p<0.05$), builds confidence in learning subject ($p<0.05$) , enables the learners develop skills necessary for more advance study of research ($p<0.05$), promoted the development of scientific thinking in students($p<0.05$) and enabled the students to answer the given questions correctly ($p>0.05$). The laboratory methods did not help students answer the given questions

correctly (p>0.3926).

Table 1.4: Effects of laboratory method on Mathematics performance

Statement	Respondents	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Chi-Square (χ^2)
Made the students to retain the learned concept longer	Learners	32 (15.38%)	163 (78.37%)	1 (0.48%)	8 (3.85%)	4 (1.92%)	χ^2 = 218.45 d.f.=4 p= 0.0001
	Teachers	4 (15.38%)	19 (73.08%)	2 (7.69%)	1 (3.85%)	-	χ^2 = 125.36 d.f.=3 p = 0.0001
Enabled the leaners to understand the concept better than before	Learners	67 (32.21%)	129 (62.02%)	2 (0.96%)	8 (3.85%)	2 (0.96%)	χ^2 = 144.3 d.f.=4 p = 0.0001
	Teachers	8 (30.77%)	16 (61.54%)	1 (3.85%)	1 (3.85%)	-	χ^2 = 91.47 d.f.=3 p = 0.0001
Helped in removing abstractness	Learners	61 (29.33%)	113 (54.33%)	3 (1.44%)	24 (11.54%)	7 (3.37%)	χ^2 = 97.5404 d.f.=4 p = 0.0001
	Teachers	2 (7.69%)	14 (53.85%)	6 (23.08%)	3 (11.54%)	1 (3.85%)	χ^2 = 81.44 d.f.=4 p = 0.0000
Boosted the performance	Learners	48 (23.08%)	142 (68.27%)	1 (0.48%)	8 (3.85%)	9 (4.33%)	χ^2 = 161.23 d.f.=4 p = 0.0001
	Teachers	6 (23.08%)	18 (69.23%)	1 (3.85%)	1 (3.85%)	-	χ^2 = 112.86 d.f.= 3 p = 0.0001
Increased effective teaching and learning	Learners	52 (25.00%)	112 (53.85%)	6 (2.88%)	24 (11.54%)	14 (6.73%)	χ^2 = 85.15 d.f.= 4 p = 0.0001
	Teachers	7 (26.92%)	14 (53.85%)	1 (3.85%)	3 (11.54%)	1 (3.85%)	χ^2 = 89.04 d.f.= 4 p = 0.0001
Builds confidence in learning subject	Learners	63 (30.29%)	104 (50.00%)	8 (3.85%)	18 (8.65%)	15 (7.21%)	χ^2 = 77.30 d.f.= 4 p = 0.0001
	Teachers	8 (30.77%)	13 (50.00%)	1 (3.85%)	4 (15.38%)	-	χ^2 = 48.08 d.f.= 3. p = 0.0001
Enables the learners develop skills necessary for more advance study of research	Learners	52 (25.00%)	124 (59.62%)	8 (3.85%)	8 (3.85%)	16 (7.69%)	χ^2 = 114.03 d.f.= 4. p = 0.0001
	Teachers	6 (23.08%)	18 (69.23%)	1 (3.85%)	1 (3.85%)	-	χ^2 = 112.86 d.f.= 3. p = 0.0001
Promoted the development of scientific thinking in students	Learners	53 (25.48%)	137 (65.87%)	2 (0.96%)	5 (2.40%)	11 (5.29%)	χ^2 = 152.55 d.f.= 4 p = 0.0001
	Teachers	8 (30.77%)	18 (69.23%)	-	-	-	χ^2 = 14.44 d.f.= 1 p = 0.0001
Enabled the students to answer the given questions correctly	Learners	32 (15.38%)	45 (21.63%)	43 (20.67%)	33 (15.87%)	55 (26.44%)	χ^2 = 4.100 d.f.= 4. p = 0.3926
	Teachers	3 (11.54%)	6 (23.08%)	12 (46.15%)	5 (19.23%)	-	χ^2 = 26.00 d.f.= 3 p = 0.0000

Standardized Mathematics Achievement test (MAT) pre- test control and experimental; for the extra county school, the pre-test control mean mark was 11.09ffl1.21 while the pre-test experimental was 11.91ffl1.35 with no significant difference between pre-test control and pre-test experimental (t= -3.0514, p=0.2354). For the County Secondary school, MAT for the control pre-test was 7.24.38ffl0.83 while the experimental pre-test was 8.10ffl1.08 with no significant difference between the two (t= 1.9137, p=0.2310).For the private school, the pre-test control mean mark was 9.0ffl1.31 while the pre-test experimental was 10.44ffl1.27 with no significant difference between pre-test control and pre-test experimental (t= -3.1405, p=0.3534).

Table 1.5: Pre-test for control and experimental Standardized Mathematics Achievement test (MAT)

	Pre-test control mean mark (%)±SE	Pre-test experimental mean mark (%) ±SE	Students t-test	p-value
Extra County	11.09±1.21	11.91±1.35	3.0514	0.2354
County	7.24.38±0.83	8.10±1.08	1.9137	0.2310
Private	9.0±1.31	10.44±1.27	-3.1405	0.3534

The Standardized Mathematics Achievement Test (MAT) post-test control and post-test experimental yielded the highest mean score (23.08ffl1.96), which was significantly higher than the post-test control (t=-23.1253, p=0.0013), which recorded a mean score of 18.45ffl1.74. The highest mean score in the county school category, 13.13ffl1.22, came from the post-test experimental group and was noticeably higher than the post-test control group's (9.38ffl1.38; p<0.05) mark. The private school means under study showed the same. Different types of schools, which are mostly influenced by infrastructure development and entry marks could be the cause of the disparity in means. Hypothesis (H01) anticipated association absence between student performance and laboratory method. The findings indicate a significant correlation between student performance and laboratory method (p<0.05), rejecting the null hypothesis.

Table 1.6: Post-test control and post-test experimental Standardized Mathematics Achievement test (MAT)

	Post-test control mean mark (%)	Post-test experimental mean mark (%)	t-test	p-value
Extra County	18.45±1.74	23.08±1.96	-23.1253	0.0013
County	9.38±1.38	13.13±1.22	-21.1643	0.0021
Private	9.94±1.22	12.99±1.29	-33.9463	0.0015

Discussion

Laboratory methods of teaching Mathematics have shown to greatly influence student performance. It has proven that student is able to retain the learned concept longer when taught using the method. Moreover, student understanding of the concept has been made better than before when using conventional method understand the concept better than before. The finding also agrees with those of Okeke & Okigbo (2021), they stated that laboratory instruction help students create concepts through experience with physical things. This is consistent with Uzezi & Zainab (2017) conclusion that "activity-oriented learning" helps students understand and retain information because they actively engage in lessons through laboratory experiments, question-answering opportunities, and other opportunities to explore, justify, and elaborate their viewpoints.

The finding also indicated that laboratory method in in removing abstractness. This is consistent with Desoete et al. (2019) they stated that Mathematics laboratories provided quick access, eliminated abstraction, and improved effective teaching and learning. Also, Hadar & Tirosh (2019) and McCulloch et al. (2018) found out that Mathematics laboratory will help to lessen the abstract nature of the subject and enable students to grasp concepts. The finding has shown that Mathematics laboratory boost the performance; similar finding by Evans et al. (2022) and Hernández-de-Menéndez et al. (2019) demonstrated that the Mathematics Laboratory way of teaching and learning mathematics was superior to the lecture method in terms of student achievement.

The results show it increases effective teaching and learning and builds confidence in learning subject by students. The finding agrees with those of Das (2019); Njoroge (2022); Okeke & Okigbo (2021) the state that Mathematics lab improves students' capacity to complete their assignments and engage in other activities that offer active mathematical experiences using their senses. The finding also showed that the method enabled the learners develops skills necessary for more advance study of research and also promoted the development of scientific thinking. The finding by Evans et al. (2022); Hassler Hallstedt et al. (2018); Njoroge (2022) indicated that laboratory work in mathematics gives students the necessary practical skills. The finding is similar to those of Hwa (2018) where the lecture style used in schools isolates pupils from one another, which causes a high failure rate in the sciences and Mathematics.

The Standardized Mathematics Achievement Test (MAT) post-test control and post-test experimental yielded the highest mean score, which was significantly higher than the post-test control. Finding by (Hadar & Tirosh, (2019); Hernández-de-Menéndez et al. (2019); Hwa, 2018) are

similar to the researchers finding. They have indicated that Mathematics laboratory improves performance. The finding also agrees with Njoroge (2022) when a teacher adapts their teaching style to one that is more student-centered, good improvements occurs.

Conclusion

The study shows that students' total mean mathematical achievement was considerably impacted by the laboratory method of instruction. The experimental group had higher mean achievement as compared to the control group, which received conventional Math education. The laboratory method of instruction had a considerable impact on students' mathematical performance for the topics of reflection and congruence, according to both teachers and students. This is attributable to the method's ability to assist students to retain new information for longer periods, help them understand it more thoroughly than previously, help eliminate abstractness, improve performance, allow for the use of sophisticated tools, and let students practice new abilities. The Standardized Mathematics Achievement Test (MAT) pre-test experimental group showed significantly superior performance than the control group in the theme of reflection and congruence, according to the assessment of student performance for the three types of schools.

Recommendation

Teachers of Mathematics should include the laboratory method as one of the methods used in the topics of reflection and congruence as well as other mathematics-related topics. In order to ensure that students engage in the laboratory method to improve performance in an examination setting more frequently, practical examinations should be introduced in all classes.

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The Effects Of Computer Simulation On Learners' Academic Performance In Physics In Selected Secondary Schools In Kangundo Sub-County

ABSTRACT

Academic performance of physics in secondary schools is lower compared to other subjects and some of the mentioned possible reason was due to teacher's pedagogical approaches. The study was conducted in Kangundo sub-County, adopting nonequivalent group pre-test post-test quasi experimental design. It targeted 1560 Form one physics students and 31 physics teachers. The data collection tools were; the Standardized Physics Achievement Tests, Teacher and Student questionnaire. Content validity of research instruments were achieved through expert judgment by university supervisors while reliability of the tools was achieved through test-retest technique. The sample size of 130 students in 3 selected schools taught with computer (experimental group) and 130 students in 3 selected school without computer (control group) were selected as respondents. Both descriptive and inferential statistics were used to analyze data in this study. Preliminary quantitative data was analyzed by calculating the mean, standard deviation and the percentages. The researcher also applied t- test, and chi-square for quantitative data. From the data collected, majority of respondents agreed that there were enough computers for use in the school. For the statement that all students have equal chance of use of computers, majority of the learners disagreed but teachers however strongly agreed with the same statement *($\chi 2$ = 16.34, d.f.=1, p= 0.0003)*. On the statement that the instructional method used has made Physics topic easy, *majority* of the learners and teachers agreed. Pretest results showed no significant mean difference meaning that the two groups were equivalent in ability. Pretest results for the control group in extra county school mean mark was 9.33ff10.49 while the pre-test extra county experimental group was 9.16ff10.05 with no significant difference *(p=0.0899)*. Similarly, private as well as the County Secondary schools showed no significant difference. For post-test control group, extra county school mean mark was *10.16±3.05* while post-test experimental group extra county school was *13.80±0.06* with a significance difference *(t=-15.1425, p=0.0043)*. For the private secondary schools, the mean mark for control group post–test was *8.36±0.57* while the post-test experimental group of the same was *10.43±0.19* with a significance difference between the two *(t =-43.6394, p=0.0005)*. For the county secondary school, the mean mark for control group post-test was *6.37±0.38* while post-test experimental group *was 7.31±0.38* with a significance difference *between the two (t=-22.1560, p=0.0020)*. It was extrapolated that computer simulation was suitable method for enhancing learners' academic performance in physics than the conventional method of teaching. The researcher recommended that the Computer simulation method be adopted by physics teachers in delivering physics concepts thus improving students' performance.

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Introduction

The engagement with pupils that facilitates their understanding and application of knowledge, concepts, and practices is known as teaching. It entails design, selection of the subject matter, delivery, assessment, and reflection (Jaiswal, 2019). On the other hand, learning is described as the process of

acquiring knowledge or abilities through study, practice, instruction, or personal experience (Alam, 2022). An instructional process is made up of teaching and learning activities that are specifically designed to transfer desired knowledge, skills, and values over a certain period of time in order to improve learners' achievement in the subject matter. It takes into account students' academic success, how well they use the time allotted to them, and how actively they participate in the session.

Physics is a science subject taught in Kenya and other parts of the world (Otieno, 2019). In Kenya it is compulsory in form1 and 2 and is optional to form 3. Physics was taught by conventional methods then after sometime it evolved to computer and it is still advancing with new technology. Physics is well taught when the learners are using their senses of hearing and seeing because by seeing the learners remember hence retaining the knowledge more but by hearing they may forget what they learnt (Model, 2022).
Performance of physics in secondary schools is lower compared to other subjects and some of the mentioned possible reasons is due to learners' negative perception towards physics subject and teacher's pedagogical approaches (Amunga et al., 2011). It has further been pointed out that teacher centered approaches has negatively affected learning of physics. There is therefore a need for a paradigm shift to student centered pedagogical approach and simulation is one of the techniques that is found to enhance achievement among learners in mathematics, technology and home science subjects in Kenya (Sifuna, Manyali, Sakwa & Mukasia, 2016). Mang'eni (2018) documented that physics was having low enrolment and it is a major setback for its benefits since it is a core subject in modern world. Computer simulation is reported to enhance learners' performance however, it is not known the extent to which it affects learners' performance.

Performance in Physics in Kenya has ranged from moderate to below average and Kangundo sub-county is not exceptional. For example, there has been continuous poor performance in physics country wide in the available data for 2016-2018 from Kenya National Examination Council (KNEC) reports. Paper 1 of physics exam has also been declining throughout these years. The researcher chose one topic set in paper 1 which helped conduct this study with an aim to counteract this failure. Teacher centered approach was presented by Guloba, Wokadala and Lawrence (2010) to be the most cause of low grades in physics in national exam. Oladejo, Ojebisi, Olosunde and Isola (2011) also echored that there was poor performance in physics and that over the years, secondary schools physics test scores have been dropping. All these arguments pointed to the requirement for instructional process which the study sought to answer.

Ayiema, Mwoma and Aouko (2019) determined that teachers with positive attitude towards science were found to use instructional resources more effectively than the negatives ones. According to Njiru and Karuku (2015), learner factors also contributed to the poor performance. Computer simulated models were therefore found to encourages individualized learning which leads to changes in learners' prior knowledge (D'Angelo, Rutstein, Harris, Haertel, Bernard & Borokhovski, 2014). Computer simulations is a powerful learning tool that actively involved learners in learning hence enhancing performance as compared to learning through listening and reading (Erhel & Jamet, 2019). Simulation also presented opportunity for learners to see situations that were not necessarily visible (Smetana & Bell, 2012).

Hakeem (2001) documented how students performed business statistics course while using simulation method. In his finding, he noted that those using simulation performed better than those who didn't use the method. Similar ideas are echoed by Kreber (2001) who argues that simulation as a technique of teaching promotes critical thinking abilities and self-directed learning among learners. Rocha (2019) in his study of star formation confirmed the advantages of simulation method of teaching and learning geography by providing how the engaged students perceived themselves. This establishes that students who learn through simulation process were able to perceive themselves as more competent to their peers who did not have an opportunity to be taught through this method.
Alenezi (2019) advanced that simulation affects the quality of instruction and how well students learn. He discovered that simulation improved both teaching effectiveness and student learning outcomes. He then recommended that teachers and students in Saudi Arabia should adopt simulation technique to enhance their classroom outcomes. Smetana and Bell (2012) presented a case that computer simulation may be used to complement conventional training in science classes to improve student subject understanding and induce conceptual shift by allowing students to view scientific phenomena that are difficult to precisely observe in real life. Nyamu, Gatere and Kithinji, (2018) affirmed that in nursing education in Kenya medical training, simulation presented to be a positive method of teaching and learning. Mihindo, Wachanga and Anditi, (2017) also confirmed the same in chemistry subject in Kenyan schools. This study thefore intended to establish if the same can be applied in teaching physics.

Kenya National Examination Council (KNEC) 2018 physics reports have indicated poor performance for the previous four years in the physics course nationwide. This location was ideal for the study since it showed continuous poor performance in physics subject as evidenced in KNEC physics report of 2018. The area was chosen for the study because the indigenous people living in Kangundo are of Akamba ethnicity however, due to the proximity to Nairobi, the area was highly inhabited by other communities making it cosmopolitan.
It was asserted that poor performance in physics subject was attributed to the way physics concept was delivered in class. Musasia, Ocholla and Sakwa, (2016) presented that lecture method was

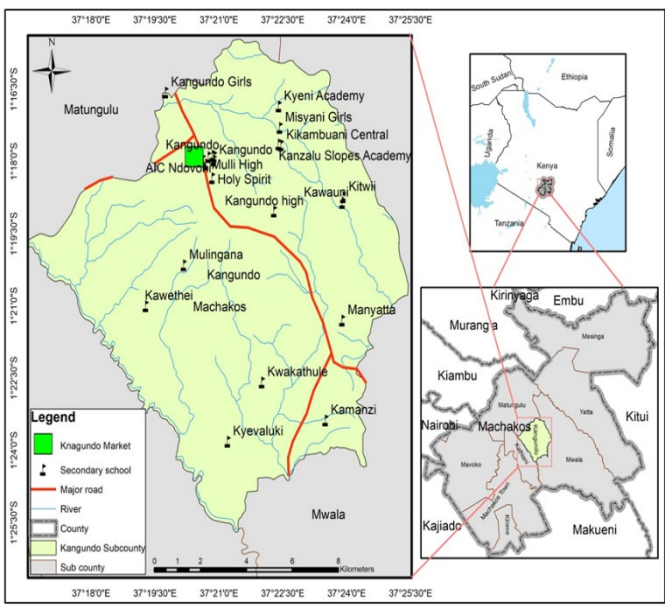
predominantly used by physics teachers. This hindered learners the opportunity to explore and come up with their findings on how physics works. It is believed that effective teaching methods boosts learners' performance. For this reason, the study sought to determine how computer simulations affected students' academic performance in physics at particular secondary schools in the Kangundo subcounty.

The study findings will effectively guide Ministry of Education (MOE) policy makers in advancing methods of teaching for different subjects. It will as well assist curriculum planners and developers in deciding on effective methods of teaching. Therefore, Kangundo sub-county and all Kenyan physics teachers will understand where to put more emphasis and how to maximumly use the computer simulation techniques in instructional process. This study will also help learners in their day-to-day life by relating what they learnt in school with what really exist in the real life.

Research methodology

Study Area

The study was conducted in Kangundo subcounty, one of the 8 subcounties in Machakos County. The subcounty is located in the eastern part of Kenya between latitude: -1° 17' 52.51" S and longitude: 37° 20' 49.38" E it is located 63km southeast of Nairobi. The subcounty has the following administrative wards: Kangundo North; Kangundo Central; Kangundo East and Kangundo West.



Study area map

Research Design

The study adopted nonequivalent group pre-test post-test quasi experimental design advanced by Reichardt (2019). Due to the existing of classes as intact groups, this design was used. Again, secondary schools in Kenya currently are not using computer simulation techniques of teaching, this design allowed the researcher to introduce the use of computer simulated models in classroom and test its significance. The design was aimed at determining if the treatment applied to the experimental group impacted the study findings (Creswell & Creswell, 2017).

Table 3:1 Research design description

Group	Pretest	Treatment	Posttest
Control		C	
Experimental		X	

Key

X-computer simulation instructional method
C-Conventional method
Subjects in control and experimental group did the pretest and posttest.
The design was chosen because it allowed the comparison of the final posttest results between the 2 groups, giving an idea of the overall effects of the treatment. In the research, the experimental group received the treatment X. The second set of students received traditional instruction. Results from the post-test for both groups were compared.

Research methodology

This study employed mixed methods where by quantitative research endeavored to establish the relationship between the effects of computer simulation an independent variable on instructional process of physics as dependent variables among selected form 1 students. Qualitative research was employed to enable researcher record observations on learners' participation and that of time usage as per the lesson plans of the physics lesson in selected schools taught with computer and those without. The teaching was done by the regular physics teachers from the sample schools. The teaching and learning took place for three weeks. An opinion of the experimental group was gathered after the application of computer simulation using Student Questionnaire (SQ).

Target Population

The study targeted 1560 students in form one classes and 31 physics teachers in 31 Kangundo sub-county secondary schools. Form one physics teachers were targeted to offer teaching on the topic under study as well as involving learners in learning by conventional methods and or computer simulation. Physics teachers also provided information on learners' performance in physics and any other information on availability and use of computer in the physics subject. Form one physics students were chosen since the content under study is in form one physics syllabus. They were also the ones taught and did the tests.

Sampling Procedure

In respect to IEBC 2013 Kangundo subcounty is divided into 4 wards namely; Kangundo North; Kangundo Central; Kangundo East and Kangundo West The researcher stratified kangundo subcounty into 4 wards and 2 wards were chosen randomly by writing the names of wards in 4 pieces of papers and folding them. They were put in a container, shaken and 2 picked randomly to represent the sample wards. According to chepkwony 2019, Kenya secondary school are grouped into 4 categories namely; national, extra county, county and private schools. Kangundo has extra county, county and private secondary schools. In the 3 categorization of schools, in each there are those with computer and those without computers. In each category of school, 1 with computer and 1 without computer were chosen randomly. All teachers teaching physics in the selected form 1 secondary schools were purposefully chosen as respondents.

Purposively, school was chosen on the basis of having computers and those without giving priority to only those with functioning computer labs. Likewise, only form one students in those schools offering physics and computer lesson were regarded. The schools offering the computer and physics subjects was then sampled randomly to come up with working sample schools.

Purposively, form one Physics teachers selected taught the topic Pressure and involved learners in learning by conventional methods and or computer simulation in their respective groups.

Sample size

Total number of students and teachers used in the research were determined using Mugenda and Mugenda (2003) who concluded that 10% to 30% respondents from the target population would make a suitable sample size for the study. 6 teachers out of 31 and 230 students out of 1560 students in the selected secondary schools in Kangundo subcounty formed the sample of the study.

Data Collection Instruments

Data collection instruments refer to the items or tools used by researcher to collect data (Canals, 2017). The study used the following research instruments; Standardized Physics Achievement Tests (SPAT), Teacher and Student questionnaire.

Validity and Reliability

The researcher used expert judgement to assess content validity of research findings. Apart from content validity, construct validity was also essential. The researcher conducted piloting which existed as a form of pretest that ensured construct validity of the study findings.
Reliability of the questionnaire and tests were determined through the use of test-retest technique. The researcher administered pre-test (before treatment) and post- test (after treatment) exams of equivalent form to learners with the help of the selected teachers in respective secondary schools. The scores were then correlated by the researcher using Cronbach's alpha test on the reliability command in SPSS. It was accepted since it yielded correlation coefficient (0.801) that is above 0.7 that is; (Madan & Kensinger, 2017).

Data Collection Procedures

By use of demonstration, the researcher inducted selected teachers in experimental schools on how to teach the topic of pressure using computer simulation for 2 days. Researcher then specified the topic on which the comparison was to be made and gave pretest to learners. The researcher then allowed teachers to teach under her supervision for 3 weeks so that the entire topic was covered. Lastly, the researcher gave learners the posttest with the help of the selected teachers, then issued the questionnaire and marked them on the fourth week.

Before the actual lesson, the researcher obtained lesson plans for schools to be taught with computers and those without. The researcher went to class when the lesson began and determined how the lesson was covered alongside the allocated time and on how learners participated in the lesson. Using observational checklists, the researcher was able to rate time taken as well as the learners' participation in lessons taught using computer simulation and conventional methods of teaching.

Treatment procedure

A nonequivalent pre-test post-test quasi experimental design was adopted in the study where by 130 students in 3 selected schools taught with computer was the experimental group while 130 students in 3 selected school without computer formed the control group for the study. Researcher administered the pre-test to all students before the treatment then marked the tests and establishes the learners' prior knowledge before learning on topic of pressure.

Control group (A) was then taught normally by the existing established conventional method while experiment group (B) was taught the same content using computer simulation techniques for a period of 3 weeks. The researcher was observing and recording time taken for each stage as well as the learners' participation during the lesson. At the end of the topic, posttest was administered to the control and experiment group after which marking and comparing of results for the 2 groups was done by the researcher.

At the start of the study, the researcher empirically assessed differences in the two groups that is control and experiment groups. However, the researcher found that experimental group (B) performs better than the control group (A) on the posttest, she then ruled out initial differences since the groups were in fact similar on the pretest. Questionnaire was used to collect data from physics teachers after the administration of post-test.

Data Analysis Techniques

Both descriptive and inferential statistics were used to analyze quantitative data in this study. Preliminary quantitative data was analyzed by calculating the mean,

standard deviation and the percentages. The researcher applied t-test and chi-square goodness of fit for detailed quantitative data. Qualitative data was coded and analyzed thematically.

Demographic characteristics of the respondents

There were one hundred and ninety six (196) students issued with questionnaires. Out of the total, one hundred and three (103) were female constituting the majority (52.60%). The assessed students who had not been trained on how to use a computer were majority 119 (60.70%) while the rest had been trained. Majority of the student stated that they had been using computers for a period of less than one year (85.60%) while few had been using for a period of between 1 and 2 years (4.60%) as illustrated in Table 4.1.

Table 1: Demographic characteristics of the learners

Question	Attribute	Frequency	Percent (%)
What is your gender?	Male	93	47.40
	Female	103	52.60
	Total	196	100.00
Have you been trained on how to use a computer?	Yes	77	39.30
	No	119	60.70
	Total	196	100.00
How long have you been using a computer?	None	113	57.90
	<1 years	54	27.70
	1(2 years	9	4.60
	3(4 years	9	4.60
	>4 years	10	5.10
	Total	195	100.00

For the teachers, both male and female had equal proportions (50.00%). Majority (66.70%) of teachers were in the age group of 25-35 years while a lower proportion of them were in the age group of less than 25 years as illustrated in Table 4.2. All assessed teachers had Bachelor's degree as their highest education qualification with greater than five years of experience but less than ten years (83.30%). In terms of experience in teaching Physics subject, all the assessed had been in the teaching field for less than ten years (100.00%) with majority having been trained on how to integrate ICT in teaching 5 (83.30%) as illustrated in Table 4.2.

Table 2: Demographic characteristics of the teachers

Question	Attribute	Frequency	Percent (%)
What is your gender?	male	3	50.00
	female	3	50.00
	Total	6	100.00
To what age group do you belong?	<25 years	1	16.70
	25(35 years	4	66.70
	35(45 years	1	16.70
	Total	6	100.00
What is your highest professional qualification?	Bachelors' degree	6	100.00
How many years of experience do you have in teaching physics	>5 years	5	83.30
	< 1 year	1	16.70
	Total	6	100.00
Have you been trained on how to integrate ICT in teaching Physics	yes	5	83.30
	no	1	16.70
	Total	6	100.00

Effects of computer simulation on learners' academic performance in physics

After the test, learners did the questionnaire and answered part B which asked on learners' performance in physics. Their responses were coded and analyzed afterwards as follows.

Survey responses on the effects of computer simulation on learners' academic performance in physics

To establish the effects of simulation on learners' academic performance in physics in selected secondary schools in Kangundo Sub County, the respondents were asked to rate different statements. On the statement that there are enough computers for use in the school, majority of the learners agreed 45(23.10%) with the statement while few strongly disagreed with the statement with a significant difference ($\chi^2 = 2.8$, d.f.=4, p= 0.5918). Majority of the teachers 5(83.30%) similarly agreed with the same statement with a significant difference ($\chi^2 = 43.56$, d.f.=1, p= 0.0000) as illustrated in Table 4.3.

From the study, Computer in education have become so ubiquitous today that they are being used for everything from basic computing tasks like writing a word file to high-end weather forecasting and drug discovery and everything in between. Institutions have employed computers in education for a number of purposes for a while now. They are used by teachers to gather educational resources and activities as well as student data.

Students, on the other hand, used them as sources for learning which explain why students and teachers pointed out that there were enough computers for use by leaners in Physics classes in their school. The findings are in line with those of Banik & Biswas (2017) that although using computers in the classroom for education is not new, its breadth and use have multiplied. Students nowadays have unparalleled access to electronic resources at both their classrooms and their homes.

For the statement that all students have equal chance of use of computers, majority of the learners disagreed 67(34.50%) while a low proportion of them were neutral on the statement with a significant difference (χ^2 = 14.7669, d.f.=4, p= 0.0052). Teachers however strongly agreed with the same statement (χ^2 = 16.34, d.f.=1, p= 0.0003). From the findings, using computer at schools brings significant role among students and teachers. This is evidenced by the fact that students are given an equal chance while in form one to be enrolled in computer classes in their schools. In addition, Kenya's education ministry proposed that information and communication technology (ICT) such as computers, laptops, tablets and cameras be used to help teach certain subjects and improve how students learn. The technology was intended to stimulate creativity, help children understand complex topics and give them tools to learn more independently.

Respondents were also asked whether the instructional method used in this topic was enjoyable. Majority of learners strongly agreed with the statement 90(45.90%) while few disagreed with the statement (χ^2 = 51.1969, d.f.=4, p= 0.0000). On the same statement majority of the teachers agreed 4(66.70%) with a significant difference (χ^2 = 11.56, d.f.=1, p= 0.0007) as illustrated in Table 4.3.

Instructional method used ensured that the students are attentive and this resulted to students having a positive attitude towards Physics subject. The findings are consistent with those of Kattayat, Josey, and Asha (2016), who discovered a statistically significant association between computer simulation use and attitude toward physics classes. Banik & Biswas (2017) also discovered comparable outcomes when examining the impact of computer-assisted education on students' academic performance in general science. On the statement that the instructional method used has made this Physics topic easy, majority of the learners strongly agreed 93(47.70%) followed by those who agreed 47(24.10%) while few 7(3.60%) strongly disagreed with a significant difference (χ^2 = 60.10, d.f.=4, p= 0.0000). For the teachers, majority agreed with the same statement (χ^2= 49.9581, d.f.=2, p= 0.0000). In this regard, the findings of Oymak & Bekiroghu (2017) are supported, who highlighted that when technology was incorporated into the lesson, the students improved as learners and had better attitudes. The results supported those of Mwamba, George, Moonga, and Pondo (2019), who found that physics simulations significantly improved students' attitudes and performance regarding electromagnetism topic.

On the statement that the instructional method used made learners understand the concepts more better, majority of the learners strongly agreed with the statement 97(49.70%) with few strongly disagreeing 9(4.60%) with the statement with a significant difference (χ^2 = 68.15, d.f.=4, p = 0.0000). Similarly, majority of the teachers agreed 4(66.70%) with the statement as illustrated in Table 4.3.

The findings are due to the fact that with the correct teaching strategies, teachers can make the classroom a fun and effective place for students to gain vital intellectual and social skills that will serve them for the rest of their lives. A teacher can accommodate students with a variety of interests, skills, and learning preferences by utilizing one of the various frameworks available.

To increase students' chances of success in the classroom, a teacher or other professional, find it helpful to learn about innovative instructional practices in the sector. Tarng et al. (2019) and Chen et al. (2019) indicated that due to physics' significant impact on technology programs at universities and other higher institutions of learning, demand for physics should be rising. Miheso (2020) acknowledge that low enrolment and poor performance in physics are due to a lack of inspiring and well-trained physics professors, inadequate laboratory equipment, and the concomitant insufficient exposure to practical training.

Table 4.3: Statement on the Effects of computer simulation on learners' academic performance in physics

		Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Chi square (χ^2)
There are enough computers for use in this school	Learners	30(15.40%)	45(23.10%)	42(21.50%)	45(23.10%)	33(16.90%)	χ^2 = 2., d.f.=4, p= 0.5918
	Teachers	1(16.70%)	5(83.30%)	-	-	-	χ^2 = 43.56, d.f.=1, p= 0.0000
All students have equal chance of use of computers	Learners	29(14.90%)	32(16.50%)	28(14.40%)	67(34.50%)	38(19.60%)	χ^2 = 14.7669, d.f.=4, p= 0.0052
	Teachers	3(50.00%)	2(33.30%)	1(16.70%)	-	-	χ^2 = 16.34, d.f.=1, p= 0.0003
The instructional method used in this topic was enjoyable	Learners	90(45.90%)	49(25.00%)	27(13.80%)	15(7.70%)	15(7.70%)	χ^2 = 51.1969, d.f.=4, p= 0.0000
	Teachers	2(33.30%)	4(66.70%)	-	-	-	χ^2 = 11.56, d.f.=1, p= 0.0007
The instructional method used has made this topic easy	Learners	93(47.70%)	47(24.10%)	30(15.40%)	18(9.20%)	7(3.60%)	χ^2 = 60.1, d.f.=4, p= 0.0000
	Teachers	1(16.70%)	4(66.70%)	1(16.70%)	-	-	χ^2= 49.9581, d.f.=2, p= 0.0000
This instructional method used made me understand the concepts more better	learners	97(49.70%)	51(26.20%)	21(10.80%)	17(8.70%)	9(4.60%)	χ^2 = 68.15, d.f.=4, p = 0.0000
	Teachers	2(33.30%)	4(66.70%)	-	-	-	χ^2 = 11.56, d.f.=1, p= 0.0007

Leaners also added that there were other ways that instructional method enhanced their performance in Physics which included understanding the topic better (44.90%), facilitating performance on the subject which was initially performed poorly (18.65%), the method was quite interesting thus not boring (19.60%) with a significant difference (χ2 = 45.80, d.f.=4, p= 0.0000) from those who stated that the method has led to establishments of group discussions that enhanced students interactions in the subject matter (7.45%) and that the method had led to positive attitude towards Physics subject (9.40%) as illustrated in Figure 4.1. There was no significant difference between responses of boys and girls in regard to any other ways instructional method enhanced learners' performance (p>0.05).

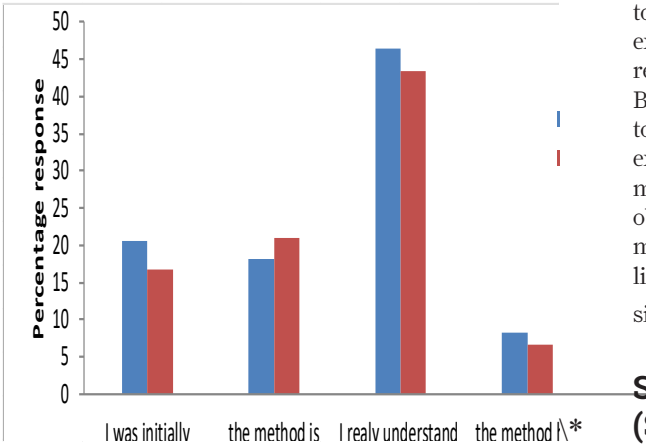


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Figure 4.1: Leaners responses on any other ways instructional method enhanced learners' performance.

For the teachers, majority added that the instructional method has led to students being more active and concentrate much on the subject (40.00%), with a significant difference (χ^2 = 12.00, d.f.=3, p= 0.0074) from those who added that the method has Encouraged students / learners teamwork (16.70%), facilitating individual handling of practical and series of tests by students (16.7%) as well as that the method enables capturing attention and interests of learners (16.7%) as portrayed in Figure 4.2.

Figure 4.2: Teachers' responses on any other ways instructional method enhanced learners' performance.

The study showed that students who were taught with computer simulated models outperformed students who were not taught the same way (conventionally) and that using simulated models generally increased students' conceptual understanding and contributed to their academic success. Teachers who employ instructional tactics such as use of simulated model, enabled students to meaningfully link ideas acquired in the classroom to actual circumstances. They provide pupils with a chance to show off their understanding and make independent course corrections as necessary.

Students in experimental group engaged with simulated models in physics and could replay the demonstrations and learn more. In general, students adhere to the guidelines in using simulated models. These instructions frequently walked students step-by-step through the experiments in topic pressure. Common learning objectives include thinking like experimental physicists and reinforcing the course material through real-world contact (demonstrations).

By separating lab exercises from the course topic, allowing students to make their own decisions, and questioning the notion of a "correct" experimental outcome, some recent initiatives have been made to move simulated (experiments) exercises in the direction of the latter objective. In contrast to the demonstration method, the laboratory methodology enables students to practice conducting experiments like actual scientists. However, in order for it to function effectively, a significant amount of time and money are frequently required.

Standardized Physics Achievement test (SPAT) pre and post test

Standardized Physics Achievement test (SPAT) pre-test was issued to the learners in different schools belonging to different categories included extra county, private and county secondary schools. There was pre- test control and pre-test experimental. For the pre-test control, extra county school mean mark was 9.33±0.49 while the pre-test experimental was 9.16±0.05 with no significant difference (t= 3.1044, p=0.0899).

For the private secondary school, the pre-test of control mean mark was 6.99±0.01 while the pre-test of experimental was 7.06±0.05 with no significant difference between pre-test control and pre-test experimental (t= -2.0604, p=0.1755).

For the County Secondary school, the mean mark for the control pre-test was 3.38±0.15 while the experimental pre-test was 3.06±0.08 with no significant difference between the two (t= 2.6047, p=0.1211) as illustrated in Table 4.4.

Table 4.4: Pre-test for control and experimental Standardized Physics Achievement test (SPAT)

	Pre-test control mean mark (%)	Pre-test experimental mean mark (%)	t-test	p-value
Extra county	9.33±0.49	9.16±0.05	3.1044	0.0899
Private	6.99±0.01	7.06±0.05	-2.0604	0.1755
county	3.38±0.15	3.06±0.08	2.6047	0.1211

There was post-test control and post-test experimental. For post-test control, extra county school mean mark was 10.16±3.05 while

post-test experimental was 13.80±0.06 with a significance difference (t=-15.1425, p=0.0043).

For the private secondary schools, the mean mark for control post–test was 8.36±0.57 while the post-test experimental was 10.43±0.19 with a significance difference between the two (t =-43.6394, p=0.0005).

For the county secondary school, the mean mark for control post-test was 6.37±0.38 while post-test experimental was 7.31±0.38 with a significance difference between the two (t=-22.1560, p=0.0020) as illustrated in Table 4.5.

Table 4.5: Post-test for control and experimental Standardized Physics Achievement test (SPAT)

	Post-test Control mean mark (%)	Post-test experimental mean mark (%)	t-test	p-value
Extra county	10.16±3.05	13.80±0.06	-15.1425	0.0043
private	8.36±0.57	10.43±0.19	-43.6394	0.0005
county	6.37±0.38	7.31±0.38	-22.1560	0.0020

According to findings, computer simulation increases the performance in physics. The finding are in line with Guy and Lownes (2015) who found a substantial difference in student performance between students taught using a hybrid format of computer simulation and those taught using the conventional method in the USA; the study came to the conclusion that those taught using computer simulations are more successful than the latter.

The finding agrees with those of Teke, Dogan, and Duran (2015), in Turkey, that computer simulations resulted to favourable impact on the academic performance of the treatment group's 7th grade students. Findings also demonstrated that training delivered through simulation had favourable results to the learner's advantage. Riaz, Naureen, and Morote (2016) looked at the relationship between simulated class management and learners' academic success in physics. For one year, 82 physics instructors at a secondary school in New York, USA, used simulations from the 2016 research, Physics Education Technology (PhET), as a teaching strategy. The results did, in fact, show a connection between simulated class management and students' academic success in physics. The study also suggested using simulated class management to boost physics students' academic performance.

The study findings also concur with those of Piraksa & Srisawasdi (2014), that simulation-based inquiry increased the understanding of physics by students about the refraction of light, in comparison with a dual-situated learning model. The post-test results showed that the treatment group did better than its counterparts in the control group.

To test the null hypothesis that there was no significant difference between learners' academic performance in physics between groups taught using computer simulation and group taught using conventional method, the research findings established the presence of a significance difference in performance with those taught using computer simulation performing better. This concluded that the null hypothesis was rejected.

Conclusion

From the results of this study, first, it can be concluded that computer simulation method was the suitable method in enhancing learners' academic performance in physics than conventional method of teaching. Computer simulation method of teaching therefore, has the ability to improve the students' retention of pressure concepts in Physics. It was further suggested that, this study should be repeated in other sub-counties in the country to ascertain consistence in the effectiveness of computer simulation method of teaching on learners' academic performance.

Recommendation

Computer simulation method should be adopted by all the physics teachers in teaching physics concepts in order to improve students' performance. This was evidenced by experimental group students' improvement in SPAT in post-test when this method of teaching was used.

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Influence Of Seed Pelleting Technique On Seed Germination In Okra (Abelmoschus Esculentus L.) Bungoma, Kenya.

ABSTRACT

In Kenya, demand for okra (Abelmoschus esculentus L.) vegegtable is greater than the supply and it is necessary to improve productivity and quality of the crop. Laboratory experiments and survey study were conducted at Mabanga Agricultural Training Institute in Bungoma County from September 2019 to January 2020 to determine the influence of seed pelleting with leaves of selected trees on seed attributes and identifying the best leaf pelleting treatment to produce high quality seeds. The experiment consisted treatments of leaves from: Albizzia amara (T1), Cassia auriculata (T2), Peltophorum ferrugineum (T3), Annona squamosa (T4), Pongamia pinnata (T5) and Azadirachta indica (T6) compared to untreated seed (T0). Pelleting treatment affected results. Seed treated with T4 had improved germination (91.67 and 95.70%), shoot length (6.50 and 8.35 cm), root length (5.00 and 9.55 cm) and vigor index (1054 and 1713.0) in okra plant. Leaf powders of Annona squamosa (T4) can be commercially utilized for enhancing the seed quality of okra vegetable.

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Key words: Okra, Treatment, Bungoma, Pelleting.

INTRODUCTION

Agriculture is the mainstay of Kenya's economy providing the basis of development for other sectors of the economy. The Agricultural sector contributes about 30% of the gross domestic product and accounts for over 75% of the total labour force (HCDA, 2013). Okra (Abelmoschus esculentus L.) is an important vegetable cultivated from the tropics to the temperate zones. Okra green fruit contain significant amounts of protein, carbohydrate, fiber, vitamin C and Ca and is a source of iodine. Supply of quality seeds to producers is essential to successful production of crop. Rapid deterioration of stored vegetable seed is a serious problem which occurs at an increasing rate in uncontrolled storage. The rate of seed deterioration can be reduced by seed treatment, coating, or pelleting with suitable chemicals, botanicals, micronutrients and biocontrol agents which reduce quantitative and qualitative loss and maintain seed quality for longer storage (Prasher et al., 2020). To promote seedling establishment, minimize yield loss, maintain and improve quality and avoid spread of harmful organisms, seed can be treated with micro- and macro- nutrients, fungicides and insecticides. Seed pelleting with botanicals are cheap and non-toxic and provide protection from pests and diseases during germination and early crop growth (Javed et al., 2021). Seed pelleting is the process of enclosing a seed with a small quality of inert material to produce a globular unit of standard size to facilitate precision planting. The material creates water holding potential and provides nutrients to young seedlings. It is more beneficial in smaller seed as singling resulting from pelleting helps reduce cost and saves seed (Ben-jabeur et al., 2021). Use of chemicals is costly and hazardous; biological control and cultural methods are less costly, easily available to farmers, safe to handle and can be easily prepared. Information on seed pelleting in field crops is available but for okra it is inadequate, there is a need to develop appropriate seed pelleting technology on development of high quality seed of these important vegetables. The experiment was conducted in a laboratory and survey to aid study of seed pelleting on physiological parameters in okra seed.

MATERIALS & METHODS

Laboratory experiments were conducted at Mabanga Agricultural Training & Research Centre in Bungoma Western Kenya, during September 2019 to January 2020 in addition to a survey questionnaire with the help of Assistant chief and village elders to local farmers (ease of communication & interpretation because we were foreign student to public) was included to cement the scientific research appropriately. The area (Bungoma County) was selected for study because vegetable production is a major economic activity in the area due to food culture and markets which serve consumers of diverse socio- economic status. Consequently, the population density is composed of readily available consumers from different backgrounds and social status who have diverse preferences. Certified seeds of Okra were obtained from Kenya seed company agro vet dealer in Mabanga Centre Bungoma County for use in the study. Seeds were pelleted with powders made from leaves of: Albizzia amara, Cassia auriculata, Peltophorum ferrugineum, Annona squamosa, Pongamia pinnata, and Azadiracta indica at 300 g· kg-1 of seed, using 10% gum arabic as an adhesive (250 to 300 mL kg-1) and dried in shade to reduce moisture content to 9%. Glass petri dishes were surface sterilized using 70% ethanol, washed then rinsed with distilled water and dried using clean cotton swabs. 3 sheets of folded filter papers were placed in glass petri dishes. Fifty seeds were counted using a clean spatula then carefully placed in each Petri dish. Stock solution was prepared (GA3 1 gram+1000 cm3 of distilled water= stock soln). Distilled water was used for the control. The treatments were: control (TO), Albizzia amara (T1), Cassia auriculata (T2), Peltophorum ferrugineum (T3), Annona squamosa (T4), Pongamia pungam (T5) and Azadiracta indica (T6). The experiment was arranged in a completely randomized factorial design and replicated 3 times. Seeds were considered germinated when the radicle was twice the length of the seed. Seed were evaluated for germination percent more so germinability was recorded 15 days after sowing (DAS) and numbers of seed germinated expressed as percent. At 7 DAS seedlings from each replication were carefully removed at random. Shoot length was measured from the collar region to the tip of the longest leaf. Root length was measured from the base of the stem to the tip of the longest root. The seedling vigor index was calculated using the formula of Abdul-Baki and Anderson (1973). Data were analyzed using GENSTAT Statistical Package F-test to determine significance among treatments.

RESULTS & DISCUSSION

Analysis of variance revealed that there were significant effects of seed pelleting on germination%, Shoot length, Root length and seed vigour index.

Germination (%) was calculated as per the rules laid out by ISTA 2021 (International Seed Testing Association). Fifty seeds from all replications of each treatment were used for conducting the germination test. This was carried out by using glass petri-dishes covered by Whatmann filter paper (white) in the seed germinator chamber at 25°C. The first and final counts were taken after 7 and 14 days, respectively.

S_0		S_3		S_6	S_9		S_{12}	Mean
	(0 month)		(Sept 2019)	(Oct 2019)		(Nov 2019)	(Dec 2019)	
T_1	2792.70		2752.03	2571.60		2384.95	2315.58	2563.37
T_2	2980.48		2947.25	2806.88		2640.38	2558.33	2786.66
T_3	2834.03		2800.15	2682.68		2599.78	2542.08	2691.74
Mean	2869.07		2833.14	2687.05		2541.70	2471.99	
Factor		T			S		T×S	
SEm±	13.61		17.57			30.45		
CD (p=0.05)	38.67		49.92			86.48		

Germination (%) was calculated by using the formula below.
Germination (%)= Number of normal seedlings ×100 / Total number of seeds.

Table 1: Effect of seed pelleting on Okra seed vigour index.

Treatments	Seed vigour index
Storage duration (Months)	

Socio economic characteristics of consumers are important in product market assessment since it influence consumption patterns of a given commodity (Leach et al., 2020). Table 2 shows the socio economic characteristics of Okra vegetables consumers. The results indicate that most of the decision making on Okra vegetable purchases are made by women as compared to men. The average age for the Okra consumers in the study area was 24.1 years (Table 2). The youngest consumer was aged 8 years whereas the oldest was aged 41 years while average retail price per kilogram of Okra leaves in the study area is Ksh.33.65. The maximum price is Ksh. 45 while the minimum price is Ksh.25 per every kilogram of Okra leaves sold.

Table 2. Socio economic characteristics of the sampled households in Mabanga, Bungoma.

Variable	Category	Frequency (N)	Percentage (%)	Min	Max	Mean		
Gender	Male	38	38	-	-	-		
	Female	61	61	-	-	-		
	Married	63	64.95	-	-	-		
Marital/S	Single	20	20.62	-	-	-		
	Widow/er	14	14.43	-	-	-		
	No eduction	9	9.09	-	-	-		
	Primary	13	13.13	-	-	-		
Education	Secondary	27	27.27	-	-	-		
	Diploma	28	28.28	-	-	-		
	Degree	16	16.16	-	-	-		
	Postgraduate	6	6.06	-	-	-		
	<10,000	1	1.03	-	-	-		
	10001-20000	8	8.25	-	-	-		
	20001-30000	12	12.37	-	-	-		
Income	30001-40000	20	20.62	-	-	-		
	40001-50000	19	19.59	-	-	-		
	50001-60000	17	17.53	-	-	-		
	>60000	9	9.28	-	-	-		
Price per KG of Okra		-	-	25	45			33.65
Age		-	-	8	41			42.21
Household size		-	-	1	12			5.48

Treatment	Germination %	Shoot length (cm)	Root length (cm)	Vigor index
Control (T0)	75.00	3.70	3.50	540.00
Albizzia amara (T1)	90.00*	3.46	4.00	671.40
Cassia auriculata (T2)	81.70	4.40	5.13*	778.60*
Peltophorum ferrugineum (T3)	81.67	4.16	4.00	666.42
Annona squamosa (T4)	91.67*	6.50*	5.00*	1054.20*
Pongamia pinnata (T5)	83.00	3.46	5.00*	702.18
Azadirachta indica (T6)	80.00	3.60	4.00	608.00
Mean	83.29	4.18	4.37	717.25
SD	5.77	1.08	0.65	166.12
SE	0.63	0.53	0.31	6.20
CD	1.27	1.06	0.62	12.40

Pelleting affected germination of Okra vegetable (Table 3). The highest percentage was due to treatment with Annona squamosa followed by Albizzia amara. The germination percent for other treatments was less. Maximum shoot length was due to treatment with Annona squamosa followed by treatments with Cassia auriculata and Peltophorum ferrugineum. The shortest shoot length was due to treatments with Albizzia amara and Pongamia pinnata. Treatment affected root length (Table 3). The longest root was due to treatment with Cassia auriculata followed by treatments T4 and T5 which were similar. The vigor index was affected by treatment with Annona squamosa having the highest vigor index followed by treatment with Cassia auriculata. Treatments T1 and T3 had similar vigor indices.

TABLE 3. Effect of seed pelleting treatments on okra

- Signifcant at 5% level

The lowest vigor index was for the control. The shortest shoots were plants developed from control seed, there were correlations between seed and plant development attributes (Table 3,4). Positive correlations occurred between germination percent, shoot length, root length and vigor index in okra. There was a significant, and positive, relationship between germination percent and root in okra. There were weak relationships between shoot length and root length and vigour indices . It is necessary to maintain a continuous supply of high quality seed to producers, produce genetically pure seed, and preserve seed quality from harvest to next sowing. Only high quality seed can better respond to inputs and management practices. Rapid and uniform field emergence is essential to increase yield, quality and profits in annual crops. Seed pelleting can be used to obtain these goals. Pre-sowing seed treatments (Mauro et al., 2021) claim to have invigorative effects for enhancing yield (Afzal et al., 2021). Pre-sowing seed management techniques include seed fortification with growth regulators, nutrients (Taylor et al., 2020), pelleting (Javed et al., 2021), osmotic priming (Taylor et al., 2020) and seed infusion (Ayenan et al., 2021). Adoption of any of these techniques for a particular crop requires standardization as responses of seed to pre-sowing treatments can vary with concentration and treatment duration. Seed pelleting with Annona squamosa maximized seed germination percent, and root length and shoot lengths and vigor index of developing plants.

TABLE 4. Correlation between germination and seedling development parameters of Okra

	Shoot length (cm)	Root length (cm)	Vigor index
Germination %	0.753	0.915*	0.740
Shoot length (cm)		0.463	0.492
Root length (cm)			0.543

Significant at 5% level

Increased quality parameters in developing plants may be due to enlarged embryos, higher rate of metabolic activity and respiration, better utilization and mobilization of metabolites to growing points and higher activity of enzymes. The presence of phenols in leaves could have promoted root length. Control had the lowest root length and might be due to low availability of nutrients in the water, increased shoot length due to seed treatment with tree leaf extracts may be attributed to cell wall extension and increased metabolic activities at low water potential, as in priming (Adrian et al., 2021). This indicates that the response could be universal across plant types. The majority of leaf powders produced phyto-stimulatory effects on enhanced seed germination and improved development of seedlings after germination. It is determined from the seed pelleting study, Annona squamosa (T4) is be recommended for improving the seed quality and seedling characters of okra.

Conclusion

Seed pelleting technique is found to be a proven method to improve Okra germination. Pelleting of fresh seeds with Rhizobium liquid culture improves seed quality parameters considerably, the analysis of variance revealed that there were significant effects of seed pelleting and germination %, shoot length, root length and seed vigour index.

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Exploring Algorithms and Mechanics of Fuzzy and Hard Clustering in Universal Cluster Analysis

ABSTRACT

A cluster is a collection of data objects which can be based on similarity to one another within the same cluster or dissimilar to the objects in other clusters. Therefore, cluster analysis refers to the grouping a set of data objects into clusters. It involves organizing data into classes such that there is both high intra class similarity as well as low inter-class similarity. Cluster analysis is a group of multivariate techniques whose purpose is to group objects (for example, test items, respondents, products, or other entities) based on the characteristics they possess. It is a means of grouping such objects based upon attributes that make them similar. If plotted geometrically, the objects within the clusters will be close together, while the distance between clusters will be farther apart. Statisticians conceptualize clustering as unsupervised classification where there are no predefined classes; psychologists conceptualize it as sorting by psychologists while marketing experts consider it as segmentation. It is the algorithmic process of finding natural groupings among objects. Cluster variate represents a mathematical representation of the selected set of variables which compares the object's similarities. Clustering may specify the relationship of the clusters to each other, for example, a hierarchy of clusters embedded in each other. There are two types of clustering thus: (1) Soft clustering (which is also known as fuzzy clustering) in which each object belongs to each cluster to a certain degree (for instance, a likelihood of belonging to the cluster) and, (2) Hard clustering in which each object belongs to a cluster or not. The paper explores the algorithms and mechanics of carrying out clustering in both hard and soft clustering.

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Conceptual issues

Cluster analysis refers to the grouping a set of data objects into clusters. It involves organizing data into classes such that there is both high intra class similarity as well as low inter-class similarity. Cluster analysis is a group of multivariate techniques whose purpose is to group objects (for example, test items, respondents, products, or other entities) based on the characteristics they possess. It is a means of grouping such objects based upon attributes that make them similar.

Cluster analysis compared to discriminant analysis

In discriminant analysis the expert should know group membership for the cases used to derive classification rules while in cluster analysis, the expert doesn't know the number of groups, does not know who or what belongs to which group.

Cluster Analysis compared to Factor Analysis

According to Aldenderfer and Blashfield (1984), cluster analysis is the grouping of objects based on the distance (proximity) while factor analysis refers to grouping that is based on patterns of variation and correlation. Typically, in factor analysis, the expert forms a group of variables based on the several examinee's responses to those variables while in contrast to Cluster analysis, we group examinees based on their responses to several variables.

Criteria for good clustering

This includes the following:

i. A good clustering method will produce high quality clusters which have (a) low inter-class similarity and, (b) high intra-class similarity.

ii. The quality of a clustering method is also measured by its ability to discover some or all of the hidden patterns and take them into account during formation of clusters.

iii. The quality of a clustering result depends on both the similarity measure used by the method and its implementation.

Common applications of clustering

We ought to mention that clustering can be applied either as (a) As a stand-alone tool to get insight into data distribution or as (b) as a preprocessing step for other algorithms.

The specific applications include (but are not limited to) the following:
Psychographic profiles: it is applied in psychographics which is a qualitative methodology used to describe consumers based on their psychological attributes. A psychographic profile is a complete profile of a person or group's psychographic make-up which is constructed using clustering techniques. These psychographic profiles are used in the design of advertisements and the process of market segmentation during which the clustering of categories of psychographic factors used in market segmentation such as activity, interest, opinion (AIOs), attitudes, values and behavior is carried out.

Applications in Psychiatry involve the application of cluster analysis in the characterization of patients on the basis of clusters of symptoms which in-turn is useful in the identification of an appropriate form of therapy to be adopted in the management of the patient's condition.

In Biology, cluster analysis is used to find groups of genes that have similar functions. This involves investigating the taxonomy of species being considered. Geneticists can collect a data set of different animals and note different attributes of their phenotypes (as influenced by the genotype). Thereafter, cluster analysis is applied in grouping those phenotypic observations into a series of clusters and from this the expert builds a taxonomy of groups and subgroups of similar animals. In Medicine, we use clustering to identify the diagnostic clusters. For this purpose, a diagnostic questionnaire has to be devised in such a manner that it includes possible symptoms (for example, in psychology, anxiety, depression etc.) and then cluster analysis can help to identify groups of patients that have similar symptoms.

Climate applications – clustering is employed to facilitate understanding the Earth's climate which requires finding patterns in the atmosphere and ocean. Specifically, cluster analysis is applied to find patterns in the atmospheric pressure of Polar Regions and areas of the ocean that have a significant impact on land climate.

Information retrieval also utilizes clustering. For instance, the World Wide Web consists of billions of web pages, and when a query is made to any of the search engines, the results can return thousands of pages. To make the search meaningful, clustering can be used to group these search results into small number of clusters, each of which captures a particular aspect (key words etc.) of the query.

In **Education,** researchers may measure psychological, aptitude, and achievement characteristics of learners then apply cluster analysis to identify what homogeneous groups exist among students (for instance, students that excel in certain subjects but fail in others, learners with special needs, exceptional ones or high achievers in all subjects) and prescribe relevant educational provisions in terms of materials, programs and processes.

TYPICAL CLUSTER MODELS

According to Bailey (1994) typical cluster models include:

1. Centroid models are clustering models which represent each cluster by a single mean vector, for example, the k-means algorithm.
2. Group models are models whose algorithms do not provide a refined model for their results and so they just provide the grouping information.
3. Connectivity models are clustering models which builds models based on distance connectivity, for example, hierarchical clustering.
4. Distribution models: here, clusters are modeled using statistical distributions, such as multivariate normal distributions used by the expectation-maximization algorithm.
5. Density models are models which define clusters as connected dense regions in the data space.
6. Subspace models which are also known as two-mode-clustering or co-clustering are applied in biclustering in which clusters are modeled with both cluster members and relevant attributes.
7. Graph-based models – in these models, a clique, that is, a subset of nodes in a graph such that every two nodes in the subset are connected by an edge can be considered as a prototypical form of cluster. An example is the Highly Connected Subgraphs (HCS) clustering algorithm where it is possible for us to relax the complete connectivity requirement and therefore a fraction of the edges can be missing (i.e. quasi-cliques).
8. In the Signed graph models, every path in a signed graph has a sign from the product of the signs on the edges. Edges may change sign and result in a bifurcated graph based on the assumptions of balance theory. The weaker "clusterability axiom" (no cycle has exactly one negative edge) yields results with more than two clusters, or sub-graphs with only positive edges.

9. Neural models: are models that can be characterized as similar to one or more of the above models, including subspace models when neural networks implement a form of Principal Component Analysis or Independent Component Analysis which normally operate as unsupervised neural network is the self-organizing map (Agrawal, Gehrke, Gunopulos, and Raghavan, 1998).

COMMON ROLES THAT CLUSTER ANALYSIS CAN PLAY

Generally speaking, cluster analysis can play the following roles:

i. Data reduction
A psychometrician may be faced with a large number of observations and data that can be meaningless unless classified into manageable groups. Cluster analysis can perform this data reduction procedure objectively by reducing the information from an entire population (or sample) to information about specific groups.

ii. Hypothesis generation
Cluster analysis is also useful when a psychometrician wishes to develop hypotheses concerning the nature of the data or to examine hypotheses that were stated previously.

Objectives of cluster analysis

Cluster analysis used with the objective of carrying out:

a. Taxonomy description that is identifying groups within the research, experimental or psychometric data
b. Data simplification which is the ability to analyze groups of similar observations instead all individual observation and,
c. Relationship Identification - The simplified structure from cluster analysis portrays relationships not revealed otherwise.

It is important to note that theoretical, conceptual and practical considerations must be observed when selecting clustering variables for cluster analysis: (i) Only variables that relate specifically to objectives of the cluster analysis are included and, (ii) variables selected characterize the individuals (objects) being clustered

Measuring the Quality of Clustering

The following are quality indicators in cluster analysis:

i. The similarity/dissimilarity metric which is sometimes expressed in terms of a distance function, which is typically metric: d(i, j)
ii. There is (apart from the cluster analysis model) a separate 'quality' function that measures the 'goodness' of a cluster that has been constructed or developed.
iii. The definitions of distance functions are usually very different for interval-scaled, Boolean, categorical, and ordinal variables.
iv. Cluster analysis weights should be associated with different variables based on data semantics and applications.
v. Cluster analysis is usually very subjective and therefore it can be quite hard to define what is 'good enough' or 'similar enough'.

How cluster analysis works

As mentioned earlier, the goal of cluster analysis is to define the structure of the data or objects by placing the most similar observations into groups. In order for this task to be accomplished, we must first answer the following three fundamental questions:

1. How can we measure similarity among the observations in the data sets?
2. How do we form clusters that are good enough?
3. How many groups do we form?

Let us then descriptively answer those questions here below.

1. Measuring similarity among the observations

The question at this point is, what measure of inter-object similarity is to be used and how is each variable to be 'weighted' in the construction of such a summary measure? Here, similarity represents the degree of correspondence among objects across all of the characteristics used in the analysis. It is in essence a set of rules that serve as criteria for grouping or separating items and it can be established using any of the following methods:

(a) Correlational measures – which involves the computation of correlation coefficients between objects where large values (and statistically significant coefficients) of r's indicate similarity. However, this method is not used frequently.

(b) Distance Measures.

Distance measures (determination of d(i, j)) is the most often used as a measure of similarity, with higher values representing greater dissimilarity (distance between cases) as opposed to similarity between objects.

Two distance graphs may have the same r = 1, which implies to have a same pattern but the distances (d's) may not be equal.

Several distance measures are available and each method has specific characteristics. They include:

i. The Euclidean distance which is recognized as the straight- line distance and it is the most commonly used distance measure. In this method, the distance between two objects is given by the formula:

$$d_{Euclidean}(B,C) = \sqrt{(x_B - x_C)^2 + (y_B - y_C)^2}$$

In other notations, the Euclidean distance function measures the 'as-the-crow-flies' distance and the simpler version of the formula for this distance between a point X (X_1, X_2, etc.) and a point Y (Y_1, Y_2, etc.) is:

$$d = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

ii. Squared Euclidean distance which is a metric that uses the same equation as the Euclidean distance metric, but does not take the square root. Therefore clustering with the Euclidean Squared distance metric is faster than clustering with the regular Euclidean distance. The consequences of using this metric is that it affects the output of hierarchical clustering which is likely to change but the output of K-Means and the Jarvis-Patrick clustering is not affected if Euclidean distance is replaced with Euclidean squared .

iii. Manhattan (city- block) distance. This Euclidean distance uses the sum of the variables' absolute differences. The Manhattan distance function calculates the distance that would be traveled to get from one data point to the other if a grid-like path is followed. The Manhattan distance between two items is the sum of the differences of their corresponding components. The formula for this distance between a point X= (X_1, X_2, etc.) and a point Y= (Y_1, Y_2, etc.) is:

$$d = \sum_{i=1}^{n} |x_i - y_i|$$

Alternatively we can say:

$$d_{City-block}(B,C) = |x_B - x_C| + |y_B - y_C|$$

The diagram below illustrates the comparative 2-D paths for the Manhattan distance and Euclidean distance

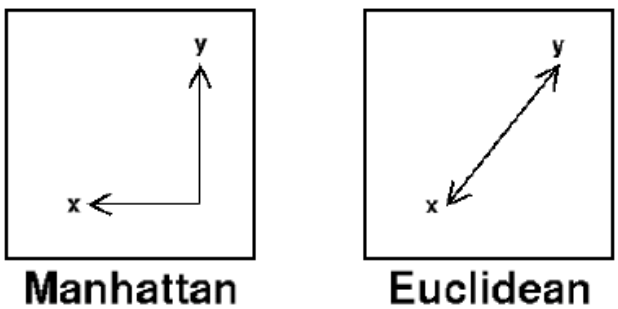


Figure 32: Comparative 2-D paths for the Manhattan distance and Euclidean distance

iv. Chebychev distance. This is the maximum of t he absolute difference in the clustering variables' values and it is frequently used when working with metric (or ordinal) data. The distance is computed using the formula:

$$d_{Chebychec}(B,C) = \max(|x_B - x_C|, |y_B - y_C|)$$

v. Mahalanobis distance (D2 or d_m) is a generalized distance measure that accounts for the correlations among variables in a way that weights each variables equally.

The equation below shows the Mahalanobis distance for a two dimensional vector with **no covariance.**

$$d(x,c) = \sqrt{\frac{(x_1 - c_1)^2}{\sigma_1^2} + \frac{(x_2 - c_2)^2}{\sigma_2^2}}$$

However, the general equation for the Mahalanobis distance uses the full covariance matrix, which includes the covariances between the vector components. Below is the general equation for the Mahalanobis distance between two vectors, x and y, where S is the covariance matrix.

$$d_M(x,y) = \sqrt{(x-y)^T S^{-1}(x-y)}$$

The computation and the measures of the distance between objects is expected to reflect the following properties: Symmetry i.e. D(A,B) = D(B,A) Constancy of Self-Similarity i.e. D(A,A) = O Positivity (Separation) i.e. D(A,B) = O If A= B Triangular Inequality i.e. D(A,B) ⧺ D(A,C) + D(B,C) From the above properties we can derive the following intuitions D(A,B) = D(B,A) that is Symmetry Otherwise one could claim 'Logan looks like Merc, but Merc looks nothing like Logan.' D(A,A) = O that is Constancy of self-similarity otherwise one could claim 'Logan looks more like Merc, than Merc does.' D(A,B) = O II f A=B that is Positivity (Separation) otherwise there are objects in our world that are different, but we cannot tell apart D(A,B) ≤D(A,C) + D(B,C) that is Triangular Inequality. Otherwise we could claim 'Logan is very like Merc, and Logan is very like Carl, but Merc is very unlike Carl.' The following diagram illustrates three distance metrics that were described earlier.

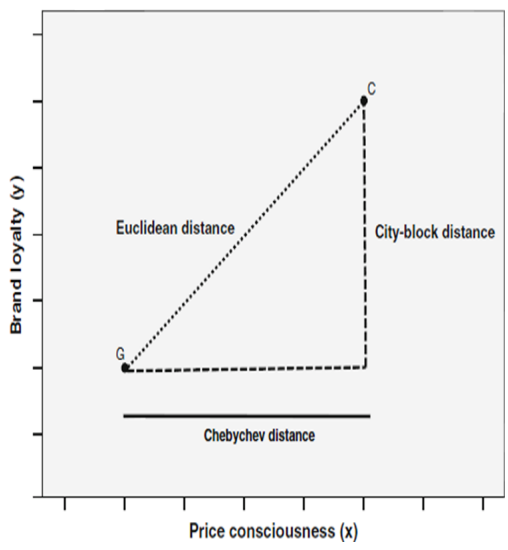


Figure 33: Three Euclidean distance metrics in cluster analysis

2. Formation of clusters (second question)

The second question is, after inter-subject similarities are obtained, how are the classes formed? This addresses the issue of class formation. Stated differently, what summary measures of each cluster are appropriate in a descriptive sense; that is, how are the clusters to be defined?

Normally one should identify the two most similar (closest) observations not already in the same cluster and combine them. This rule should be applied repeatedly to generate a number of cluster solutions, starting with each observation as its own 'cluster' and then combining two clusters at a time until all observations are in a single cluster. This process is a hierarchical procedure because it moves in a stepwise fashion to form an entire range of cluster solutions. It can also be viewed as an agglomerative method because clusters are formed by combining existing clusters (Theodoridis and Koutroubas 1999).

3. The number of groups to be formed (Third question)

The decision about the number of groups to be formed depends on the **Overall Similarity Measure** (Average Within-Cluster Distance) OSM changes in the output table of the agglomerative process and cluster solution.

We scrutinize the cluster solution to identify the step that has the most appropriate cluster solution which possibly gives us a number of equally sized clusters and few outlying observations. This approach is particularly useful in identifying outliers and it also depicts the relative size of varying clusters, although it becomes unwieldy when the number of observations increases.

GRAPHICAL PORTRAYS OF THE EXTRACTED GROUPS OR CLUSTERS

A. Nested groupings

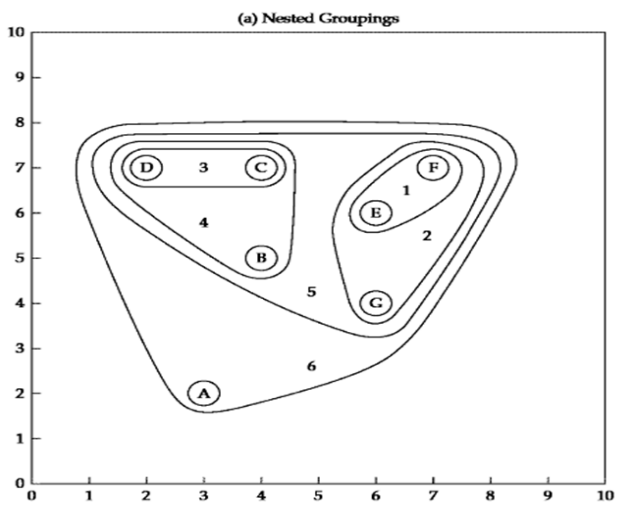


Figure 34: Graphical portray of nested groupings

A. The dendogram

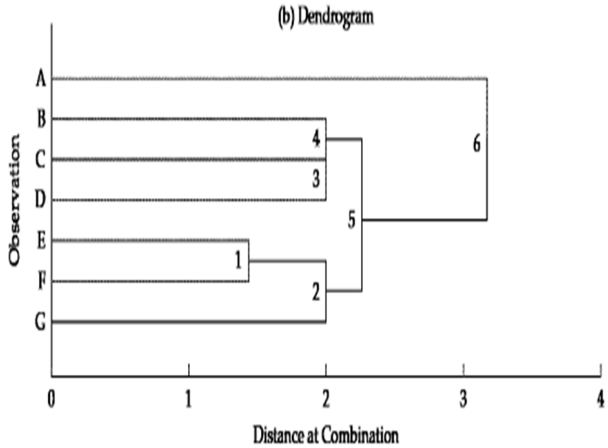


Figure 35: Graphical portray of a dendogram

The dendogram is a graphical representation (tree graph) of the results of a hierarchical procedure in clustering. Starting with each object as a separate cluster, the dendogram shows graphically how the clusters are combined at each step of the procedure until all are contained in a single cluster.

Managing outliers during clustering (Remove or to retain them)

It is important to deal with outliers because they can severely distort the representativeness of the results if they appear as structure (clusters) inconsistent with the objectives. They can either be removed or retained under the following circumstances:

(a) They should be removed if the outliers represent: Abberant observations that are not representative of the population, or, Observations of small or insignificant segments within the population and of no interest to the research objectives

(b) Outliers should be retained if there is under-sampling or a poor representation of relevant groups in the population. A good practice is to augmented the sample in order to ensure representation of these groups.

How are outliers identified or detected during clustering?

We use similarity measures to identify the outliers by:

(a) Identifying or finding the objects or observations that have large distances from all other observations.

(b) Graphic profile diagrams which highlight all the outlying cases (we can spot them from the graphs as points falling away from the cluster).

(c) Their appearance in cluster solutions as single – member or small clusters.

Sample size concerns in cluster analysis

The psychometrician should ensure that the sample size is large enough to provide sufficient representation of all relevant groups of the population. The relevant sample size calculation formulas should be applied as recommended for highly quantitative work such as cluster analysis. The psychometrician must therefore be confident that the obtained sample is representative of the population.

Standardizing cluster analysis data

Fayyad, Piatesky-Shapiro, Smuth and Uthurusamy (2008) posit that in the operations of clustering it is important to consider data standardization in managing the effects of scales. Clustering variables that have scales using widely differing numbers of scale points or that exhibit large differences in standard deviations should de standardized. The most common standardization conversion is Z score (with mean equals to 0 and standard deviation of 1).

DERIVING CLUSTERS (CLUSTER ANALYSIS METHODS)

There are different methods that can be used to derive clusters in the process of carrying out a cluster analysis; these methods can be classified as follows:

i. Partitioning algorithms (Non-hierarchical clustering) which usually construct various partitions and then evaluate them by some criterion.

ii. Hierarchy algorithms on the other hand create a hierarchical decomposition of the set of data (or objects) using some criterion.

iii. Grid-based are a clustering approach based on a multiple-level granularity structure

iv. Density-based approach to cluster analysis is based on connectivity and density functions

v. Model-based clustering approach involves hypothesizing a model for each of the clusters and the idea is to find the best fit of that model to each other.

The most commonly used clustering approaches include:

i. Partitional algorithms or Non-hierarchical Cluster Analysis

ii. Hierarchical Cluster Analysis

iii. Combination of Both Methods

Presented here-below is a description of the said approaches that are commonly used.

1. HIERARCHICAL ALGORITHMS OR HIERARCHICAL CLUSTER ANALYSIS

Hierarchical algorithms usually create a hierarchical decomposition of the set of objects using some criterion. HCA are preferred when the sample size is moderate (under 300 – 400, not exceeding 1000). Hierarchical clustering is a set of nested clusters that are organized as a tree as shown in the diagram below.

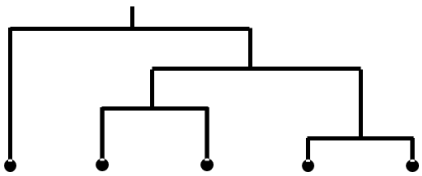


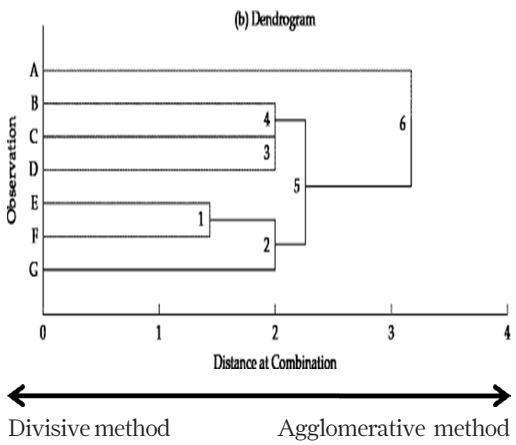
Figure 36: Hierarchical nested clusters organized as a tree

The size of the dendrograms is determined in terms of the number of its leafs. The number of dendrograms with n leafs = (2n -3)!/[(2(n -2)) (n -2)! Since we cannot test all possible trees we will have to heuristic search of all possible trees.

There are two basic forms of Hierarchical algorithms (HCA), that is (a) Agglomerative algorithm and, (b) the Divisive algorithm. An algorithm refers to a set of rules or Starting with each item in its own cluster, protocol that defines how similarity is defined between multiple – member clusters in the clustering process. A brief description of the two basic forms of HCA algorithms is as follows:

Agglomerative algorithm (Bottom-Up algorithm): this algorithm involves starting with each object point (with each item in its own cluster) as individual clusters and, at each step, find the best pair to merge into a new cluster and eventually merge the closest pair of clusters. This should be repeated until all clusters are fused together.

Divisive algorithm (Top-Down algorithm): Starting with all the data in a single cluster, consider every possible way to divide the cluster into two and then choose the best division and recursively operate on both sides. In other words, one should start with one, all-inclusive cluster and, at each step, split a cluster until only singleton clusters of individual points remain. The dendrogram below illustrates this.



Divisive method Agglomerative method

Figure 37: Dendogram illustrating divisive algorithm

Note: The Divisive Hierarchical clustering Technique is not much used in the real world and that is why not much discursive attention will be given to it in this book.

Agglomerative algorithm of Hierarchical algorithms (HCA) There are numerous clustering approaches under the agglomerative HCA but the five most popular agglomerative algorithms are:

i. Single – Linkage type of agglomerative HCA is also known as the nearest – neighbor method and it defines similarity between clusters as the shortest distance from any object in one cluster to any object in the other. Operationally it is based on grouping clusters in bottom-up at each step combining two clusters that contain the closest pair of elements not yet belonging to the same cluster as each other. This is illustrated in the figure below.

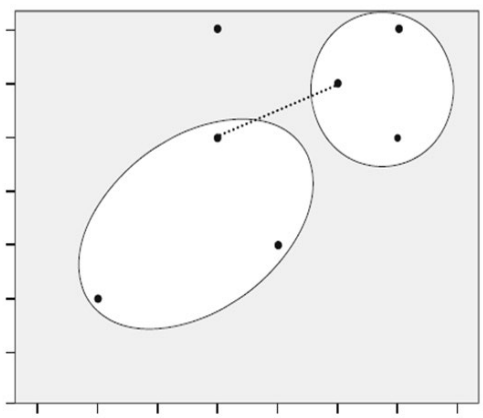


Figure 38: Single – Linkage type of agglomerative HCA

ii. Complete – Linkage algorithm (or the farthest – neighbor method). In this method of hierarchical clustering, we merge in the members of the clusters in each step, which provide the smallest maximum pairwise distance. It is based on the assumption that the distance between two clusters is based on the maximum distance between any two members in the two clusters. This is illustrated by the figure below.

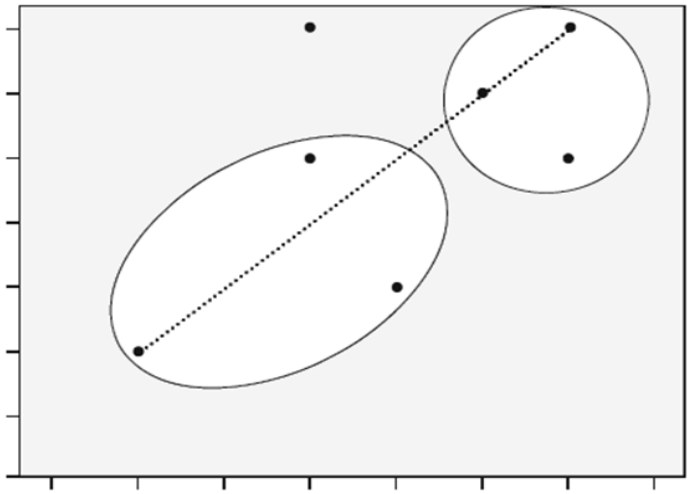


Figure 39: Complete – Linkage algorithm in HCA

iii. Average – Linkage method (i.e. Average between groups) is sometimes referred to as Unweighted Pair Group Method with Arithmetic Mean (UPGMA) in which the distance between two clusters is calculated as the average distance between all pairs of subjects in the two clusters. Most psychometricians consider this as a fairly robust method and it is is illustrated by the figure below.

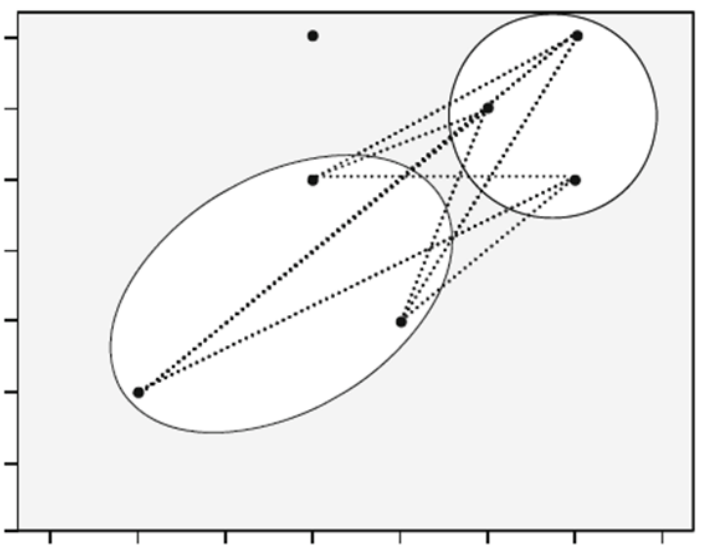


Figure 40: Average – Linkage method algorithm in HCA

iv. Centroid Method. Cluster Centroids – are the mean values of the observation on the variables of the cluster. In this type of agglomerative

HCA, the centroid (mean value for each variable) of each cluster is calculated and the distance between centroids is used. Practically, the distance between the two clusters equals the distance between the two centroids. The clustering action involves merging clusters whose centroids are closest together. This is illustrated by the figure below.

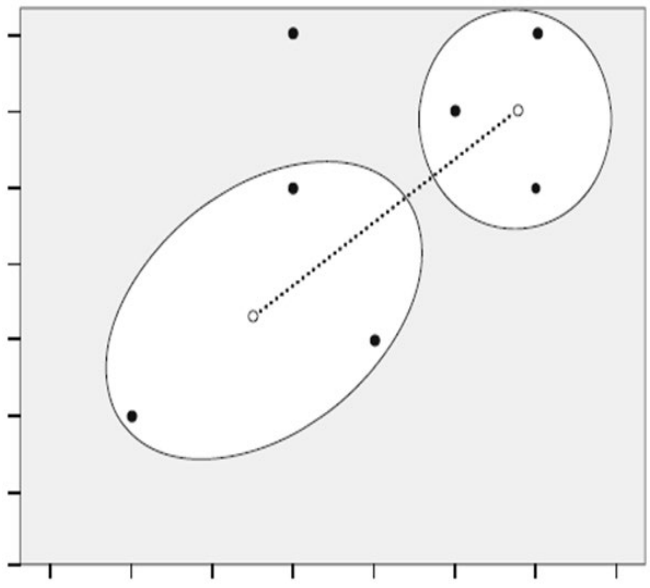


Figure 41: Centroid cluster Method

v. Ward's Method

Ward's method (also known as Ward's Minimum Variance Clustering Method or the Minimum variance method) is an alternative to single-link clustering. In this method all possible pairs of clusters are combined and the sum of the squared distances within each cluster is calculated which is then is then summed over all clusters. The combination that gives the lowest sum of squares is chosen and as a result, the method produces clusters of nearly equal size which is not always desirable. The method is quite sensitive to outliers.

Ward's method starts with n clusters, each containing a single object and these n clusters are combined to make one cluster containing all objects (MacQueen, 1967). At each step, the process makes a new cluster that minimizes variance, measured by the sum of squares index which is denoted by E At each step, the following algorithmic calculations are made to find E:

i. Find the mean of each cluster.
ii. Calculate the distance between each object in a particular cluster, and that cluster's mean.
iii. Square the differences from Step ii.
iv. Sum (add up) the squared values from Step iii.
v. Add up all the sums of squares from Step iv.

Every possible combination of clusters must be considered in order to select a new cluster at each step.

Summary of hierarchical cluster analysis

The Hierarchical Cluster Analysis provides an excellent framework with which to compare any set of cluster solutions. This method helps in judging how many clusters should be retained or considered. In summary, in Hierarchical Cluster Analysis

i. There is usually no need to specify the number of clusters in advance.
ii. The hierarchal nature of the analysis maps perfectly well onto human intuition for some domains
iii. Hierarchical Cluster Analysis approaches do not scale well considering time complexity of at least $O(n_2)$, where n is the number of total objects.
iv. Like any heuristic search algorithms, local optima in Hierarchical Cluster Analysis are a problem.
v. In Hierarchical Cluster Analysis, the interpretation of results is (very) subjective.

Advantages of Hierarchical Cluster Analysis

i. Speed. Hierarchical Cluster Analysis have the advantage of generating an entire set of clustering solutions in an expedient manner.
ii. Measures of Similarity. Hierarchical Cluster Analysis can be applied to almost any type of research question.
iii. Simplicity. With the development of Dendogram, the Hierarchical Cluster Analysis so afford the researcher with a simple, yet comprehensive portrayal of clustering solutions.

Disadvantages of Hierarchical Cluster Analysis

i. Hierarchical Cluster Analysis is not amenable to analyze large samples.
ii. To reduce the impact of outliers, the researcher may wish to cluster analyze the data several times, each time deleting problem observations or outliers.

2. PARTITIONAL ALGORITHMS OR NON-HIERARCHICAL CLUSTER ANALYSIS (NHCA)

These algorithms are simply a division of the set of data objects into non-overlapping subsets (clusters) such that each data object is in exactly one subset. It involves the construction of various partitions and then evaluating them based on some criterion (Everitt, Landau and Leese, 2001). The partitioned clusters resulting are as illustrated in the figure below where each box represents a distinct cluster.

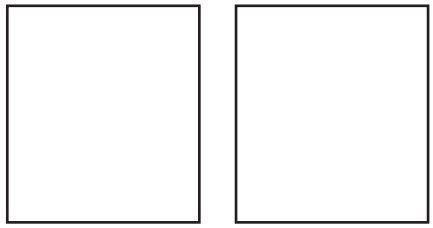


Figure 42: Non-overlapping or partitioned clusters

In contrast to Hierarchical Method, the NHCA do not involve the treelike construction process. Instead, these algorithms assign data objects into clusters once the number of clusters is specified.

Nonhierarchical cluster analysis (NHCA) is executed in two steps thus:
1.) We first specify Cluster Seed – that is, the expert identifies the starting points
2.) Assignment follows where we assign each observation to one of the cluster seeds.

The Nonhierarchical cluster analysis (NHCA) algorithm includes:
i. Sequential Threshold Method
ii. Parallel Threshold Method
iii. Optimizing Procedures
All of the above algorithms belong to a group of clustering algorithm known as K – means. The name K-means as used for Nonhierarchical cluster analysis derives from the fact that in each instance the data objects or observations are placed in exactly one of K non-overlapping clusters. In NHCA the expert has to input the desired number of clusters since only one set of clusters is output.

K - means clustering method
The term K - means is a term that is used commonly is used by some experts to refer to Nonhierarchical cluster analysis in general. Operationally, the K-means algorithm assigns each point to the cluster whose center (this center is called the centroid) is nearest. The center is the average of all the points in the cluster - that is, its coordinates are the arithmetic mean for each dimension separately over all the points in the cluster.

Algorithms of the K-means clustering
K-means clustering is a centroid-based clustering method that identifies a specified number of non-overlapping clusters within data objects or observations. It requires the psychometrician to pre-specify the number of clusters and then place each examinee into one of them. It is important to note that the actual profile (i.e., means on the variables used to cluster) of the clusters is not pre-specified, but only the number is (Jain, Murty and Flyn, 1999).

The K-means clustering algorithm is based on the following steps.
1. The psychometrician indicates the number of clusters.
2. In step two, the initial cluster centroids are formed either through pre-specification of cluster centroids by the psychometrician or by using random selection for the K clusters.
3. The squared Euclidean distance (ESS) is calculated based on the current cluster solution.
4. Each individual (or observations or objects) is reassigned to the cluster to whose centroid it is closest.
5. The cluster centroids are updated after each reassignment.
6. Steps 3–5 are repeated until no further reassignment of individuals (or observations or objects) to clusters takes place, i.e., each individual is in the cluster with the nearest centroid.
This method tries to minimize the sum of the within-cluster variances.

$$V_K = \sum_{k=1}^{K} \sum_{i=1}^{n} \delta_{ik} m_i d^2 (x_i - \bar{x}_k)$$

The indicator function χik equals 1 if the observation x_i comes from cluster **k**, or 0 otherwise. We also must reckon that the element $\bar{\mathbf{x}}_{kj}$ of the vector $\bar{\mathbf{x}}_k$ is the mean value of the variable j in the cluster $_k$:

$$x_{kj} = \frac{1}{n_k} \sum_{i=1}^{I} \delta_{ik} m_i x_{ij}$$

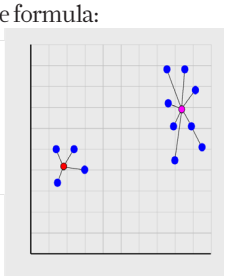
We denote the mass of the cluster **k** with **nk,** which is equal to the sum of the masses of all observations belonging to the cluster ***k***
The above criterion of the K-means clustering method can be derived in a more direct way using the Maximum Likelihood approach assuming that that there is normality and independence in the testing populations.

Illustration: The data set has three dimensions and the cluster has two points: X = (x_1, x_2, x_3) and Y = (y_1, y_2, y_3). Then the centroid Z becomes Z = (z1, z2, z_3), where $z_1 = (x_1 + y_1)/_2$ and $z_2 = (x_2 + y_2)/_2$ and $z_3 = (x_3 + y_3)/_2$.

The squared error in K-means algorithm is obtained using the formula:

$$se_{K_i} = \sum_{j=1}^{m} \|t_{ij} - C_k\|^2$$

$$se_K = \sum_{j=1}^{k} se_{K_j}$$



Objective function

Strength of the K-means method
1. The clustering method is relatively efficient: $O(tkn)$, where n is # objects, k is # clusters, and t is # iterations. Normally, $k, t << n$.
2. The K-means method often terminates at a local optimum. The global optimum may be found using techniques such as: deterministic annealing and genetic algorithms.

Weakness of the K-means method
1. *K*-means clustering is not suitable to discover clusters with non-convex shapes
2. There is need to specify k, the number of clusters, in advance and it is unable to handle noisy data and outliers
3. It is applicable only when mean is defined (ratio and interval data only) and therefore it is not applicable to categorical data.

Quality threshold clustering (QT clust) algorithm
Quality threshold clustering is an alternative method of partitioning data which was invented for gene clustering in genetics. The technical difference is that It requires more computing power than k-means, but does not require specifying the number of clusters a priori, and always returns the same result when run several times (Karypis, Han and Kumar, 1999).

The Quality threshold clustering algorithm is:

i. The psychometrician chooses a maximum diameter for clusters.
ii. Build a candidate cluster for each point by including the closest point, the next closest, and so on, until the diameter of the cluster surpasses the threshold.
iii. Save the candidate cluster with the most points as the first true cluster, and then remove all points in the cluster from further consideration.
iv. Re-curse with the reduced set of points.

Thereafter the distance between a point and a group of points is computed using complete linkage, i.e. as the maximum distance from the point to any member of the group.

Fuzzy c-means clustering

Fuzzy c-means (FCM) clustering is a method of clustering which allows one piece of data to belong to two or more clusters. The centroid of a cluster is calculated as the mean of all points, weighted by their degree of belonging to the cluster and the degree, to which an element belongs to a given cluster, is a numerical value varying from 0 to 1. FCM clustering allows each point the degree of belonging to clusters, as in fuzzy logic, rather than belonging completely to just one cluster.

Thus, points on the edge of a cluster may be in the cluster to a lesser degree than points in the center of cluster and in essence, this algorithm lumps the two clusters with natural shapes but close boundaries into a large cluster. The Fuzzy c-means (FCM) clustering algorithm is more suited to data that is more or less evenly distributed around the cluster centers and it is frequently used in pattern recognition. The FCM algorithm is different from k-means and k-medoid clustering, where each object is affected exactly to one cluster. K-means and k-medoids clustering are known as hard or non-fuzzy clustering.

In the process of pattern recognition the FCM algorithm is based on minimization of the following objective function:

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

$1 \leq m \leq \infty$

where m is any real number greater than 1, uij is the degree of membership of x_i in the cluster j, x_i is the ith of d-dimensional measured data, c_j is the d-dimension center of the cluster, and $||*||$ is any norm expressing the similarity between any measured data and the center.

Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j by:

$$u_{ij} = \frac{1}{\sum_{k=1}^{C}\left(\frac{\left\|x_i - c_j\right\|}{\left\|x_i - c_k\right\|}\right)^{\frac{2}{m-1}}} \qquad c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}}$$

$$\max_{ij}\left\{\left|u_{ij}^{(k+1)} - u_{ij}^{(k)}\right|\right\} < \varepsilon$$

When is attained, then this iteration should be stopped. Here, χ is a termination criterion between 0 and 1, whereas k are the iteration steps. This procedure converges to a local minimum or a saddle point of J_m.

Huang (1997) opines that fuzzy clustering algorithms are divided into two areas: (a) classical fuzzy clustering and (b) shape-based fuzzy clustering.

A. Classical fuzzy clustering algorithms.

There are three subtypes of classical fuzzy clustering algorithms as explained below:

i. Fuzzy C-Means algorithm (FCM). It is identical to the K-Means algorithm and it is the most widely-used algorithm. An observation or a data point can theoretically belong to all groups, with a membership function (also called a membership grade) between 0 and 1, where: 0 is where the data point is at the farthest possible point from a cluster's center and 1 is where the data point is closest to the center. Examples include and Possibilistic Fuzzy C-Means (PFCM) algorithm, the Possibilistic C-Means (PCM) algorithm and the Fuzzy Possibilistic C-Means (FPCM) algorithm.
ii. Gaussian Mixture Decomposition algorithm or the Gath-Geva algorithm which is similar to FCM, but its clusters can have any shape.
iii. Gustafson-Kessel (GK) algorithm normally associates a data point with a cluster and a matrix. The Gustafson-Kessel (GK) algorithm has elliptical-shaped clusters while the fuzzy C-means assumes the clusters are spherical.

B. Shape-based fuzzy clustering algorithms.

There are three subtypes of shape-based fuzzy clustering algorithms as explained below:

i. The Elliptical shaped fuzzy clustering algorithms which is an algorithm that constrains points to elliptical shapes and it is used in the Gustafson-Kessel algorithm.
ii. Generic shaped fuzzy clustering is an algorithm in which most real life objects are considered neither circular not elliptical and functionally the generic algorithm allows clusters to take any shape.
iii. Circular-shaped (CS) algorithms are what constrains data point to a circular shape and technically we end up with a CS-FCM when this algorithm is incorporated into Fuzzy C-Means.

Desirable properties of a clustering algorithm

As part of an evaluation checklist or a guide to the selection of an algorithm, the expert should consider the following properties:

i. The algorithm should be able to deal with noise and outliers
ii. It should have the ability to deal with different data types
iii. Consider the scalability issues (in terms of both time and space)
iv. The algorithm should insensitive to order of input records
v. It should allow for incorporation of user-specified constraints
vi. It should be easy to both use and interpret the algorithm
vii. It is desired that a good algorithm have minimal requirements for domain knowledge to determine input parameters

Advantages of nonhierarchical cluster analysis (NHCA)

i. Non Hierarchical Cluster Analysis can analyze extremely large data sets which makes it widely applicable.
ii. The results of NHCA are less susceptible to outliers in the data.

Disadvantages of nonhierarchical cluster analysis (NHCA)

i. Nonhierarchical methods are also not so efficient when there is a large number of potential cluster solutions. In contrast to the hierarchical techniques that generate all possible cluster solutions in a single analysis, in the NHCA methods each cluster solution is a separate analysis. The consequence is that the nonhierarchical techniques are not the best for use in exploring a wide range of solutions based on varying elements such as similarity measures, observations included, and potential seed points.
ii. NHCA tends to deliver different final solutions for each set of specified seed points because even in a non-random starting solution there is no guarantee that an optimal clustering of observations will be obtained.

How should the expert interpret the resulting clusters?

According to Han and Kamber, (2001) interpretation of the resulting cluster results involves examining the distinguishing characteristics of each cluster's profile and identifying substantial differences between clusters. Specific attention should be paid to the cluster centroid and a mean profile of the cluster on each clustering variable.
The psychometrician should examine the cluster solutions that fail to show substantial variation from other cluster solutions. The cluster centroid should also be assessed for correspondence with the psychometrician's prior expectations based on theory or practical experience.

Validating clusters

Validation is essential in cluster analysis because the clusters are descriptive of structure and require additional support for their relevance. Therefore in the final activities of clustering the expert should conduct this exercise. Validation is achieved through various means thus:
Validation can be achieved by examining differences on variables not included in the cluster analysis but for which a theoretical and relevant reason enables the expectation of variation across the clusters.

Secondly, cross – validation can also be employed. It empirically validates a cluster solution by randomly splitting the sample to create two sub-samples and then comparing the two cluster solutions for consistency with respect to the number of clusters and the clusters profiles.

We should also mention that clustering research into group-based orientation is commonly assessed using K-means clustering. Much as this method (K-means) has been shown to be useful and effective it does not allow the psychometrician to account for any overlaps among the clusters. The only remedy that could help address the overlap problem is the use of fuzzy clustering methods.

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Exploring the synergy of advanced manufacturing technology, competitive advantage, and organizational resources on performance: a study of large manufacturing companies in Kenya

ABSTRACT

Manufacturing companies invest in Advanced Manufacturing Technology (AMT) to improve their performance and positively contribute to GDP in their Countries. Studies have found that AMT, competitive advantage and organizational resources have a positive and significant relationship with manufacturing performance when considered as independent variables. This study investigated the joint effect of AMT, Competitive Advantage, and Organizational resources on performance of large manufacturing companies in Kenya. The study employed a descriptive cross-sectional survey. A total of 55 large manufacturing companies in Kenya that were members of Kenya Association of Manufacturers formed the population of the study. Multiple regression was used to analyze the collected data. Findings of the study show that AMT, competitive advantage, organizational resources have a very strong relationship to performance of large manufacturing companies in Kenya. Further, the study found that the joint effect of AMT, competitive advantage and organizational resources explained approximately 50% of performance in large manufacturing companies. The study concludes that there is a strong synergy between AMT, competitive advantage and organizational resources which leads to improved performance for manufacturing companies that identify strategic resources they own, adopt and implement AMT properly. The study recommends that manufacturing companies identify appropriate AMT that are in tandem with their manufacturing strategy. The results will particularly assist practitioners in identifying appropriate AMT and development of policy and manufacturing strategies in recognizing the effect of synergy between AMT, competitive advantage and organizational resources on performance in manufacturing companies.

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Key words: Advanced Manufacturing Technology, Competitive Advantage, Large manufacturing companies and Organizational Performance.

INTRODUCTION

Advanced Manufacturing Technology (AMT) continue to enable manufacturing companies develop competitive advantage and create a niche for themselves in their respective markets. Studies show that AMT has a positive and significant relationship with performance. Further, effective implementation of AMT allows manufacturing companies to develop competitive advantage and grow their market share using both cost leadership and differentiation strategies (Musebe, Awino, K'Obonyo & Kitiabi, 2020). Arising from the growth in market share by adopting AMT, manufacturing companies are able to realize improved profitability in their operations (Lim & Rokhim, 2020).

Emanating from the resource-based view (RBV) of strategy, it is instructive that Strategic resources owned by manufacturing companies and deployed in certain ways relative to competitors enable them develop and sustain competitive advantage in their industry. Companies are deemed to have successfully developed competitive advantage in their market when they consistently attain above average return on their investments for a sustained period of time (Behl, Gaur, Pereira, Yadav, & Laker, 2022). According to, Musebe, Awino, K'Obonyo and Kitiabi (2020); Marri, Irani, and Gunasekaran, (2007), AMT on its own does not make manufacturing companies develop and sustain competitive advantage in their operations.

A fit that exists between AMT and other core competencies in manufacturing companies enable them to develop and sustain competitive advantage which in turn improves their organizational performance (Kotha & Swamidass, (2000); Musebe et.al. (2020); Hyneck & Janecek, (2012); Amit and Schoemaker, (1993); Grunert & Hildebrandt, (2004)). Kotha and Orne, (1989), using conceptual models positively linked manufacturing strategy, business strategy, structure, and environment to performance of manufacturing companies

Arising from the finding by Kotha and Orne (1989), decisions involving investment and adoption of manufacturing technologies in production process are considered to be strategic. This emanates from two distinct characteristics associated with these decisions which are, being both long-term and capital intensive. Lack of strategic thinking when making the AMT investment decision contributes to the variance observed between expected and observed improvements in performance (Al-Surmi, Bashiri, & Koliousis, 2022).

The magnitude of improvement observed in performance, when applying AMT in production, determines the effectiveness of the technology used in meeting desired levels of performance. Investing in technology encourages absorptive capacity in manufacturing companies leading them to achieve stability strategies, expansion strategies, retrenchment strategies or a combination of strategies, that form part of their long-term objectives (Ren, 2019). According to Bayus, 1994; Tracey, Vonderembse, and Lim, (1998), a new competitive environment for manufacturing companies has evolved out of the factors associated with globalization, dynamic markets, increasing consumer awareness, manufacturing complexity and business uncertainty. This new competitive environment causes a shift in manufacturing strategies employed by manufacturing companies from employing efficient production systems alone to embracing AMT to offer efficient and flexible transformation of raw materials into finished products to meet particular consumer demands in their markets.

Productivity as a measure of performance in manufacturing companies can be operationalized using various concepts including; Objective concept or outcome of a process, Scientific and empirically observed concept, measure concept, efficiency concept and as a factor concept. During the industrial era, manufacturing companies used the measurement concept of productivity by practicing mass production to achieve economies of scale (Skinner, 1986). This has changed in the post-industrial era where manufacturing companies anticipate changes in the market and use flexible production systems to meet the current efficiency concept of performance (Tracey, Vonderembse, & Lim, 1998). This study used the efficiency concept by considering both financial and non-financial aspects of performance to operationalize performance.

Researchers define AMT broadly as the application of stand- alone, intermediate or integrated computer systems in the production process with the objective of improving organizational performance. This study conceptualized AMT to include design technologies, Computer aided process planning and Group technology.

According to Dollard and Bakker, (2010); Albrecht, (2012) Organizational resources can be referenced to the experiences of the "upstream" distal, contextual, or system-level aspects of the organizational environment by employees of an organization. This study conceptualized organizational resources as being system sponsored sources of supply and support that can be drawn upon by individuals and groups to help achieve psychological, attitudinal, motivational, behavioral, team, and organizational outcomes (Albrecht, Breidahl, & Marty, 2018).

Davenport (1993); Schoonhoven (1981) and Wheelwright (1978) ascertained that there is a positive relationship between technology, competitive resources and the utilization of organizational resources to performance especially for certain product functionality and cost conditions. Further, AMT provides unique opportunities for manufacturing companies related to product aspects (quality, performance, reliability, conformance, durability, serviceability) and customer needs (Variety, quality, price, functionality, availability). This study investigated the joint effect of AMT, competitive advantage and organizational resources on performance of large manufacturing companies in Kenya by developing the following hypothesis

H1: There is a significant joint effect of advanced manufacturing technology, competitive advantage and, organizational resources on performance of large manufacturing companies in Kenya.

METHODOLOGY

Arising from the literature review, a conceptual framework was developed to test the relationships between the four study variables. The study employed the positivist research philosophy in collecting and analyzing data while descriptive cross-sectional research design was adopted because of the distinctive features it has, that were important to the study (Crotty, 1998). This was a descriptive cross-sectional study that comprised 55 large manufacturing companies in Kenya and which were members of the Kenya Association of Manufacturers as at December 31st 2018. A self-administering structured questionnaire was used to collect data from the respondents in the 55 manufacturing companies and the Likert scale was used to rate the responses of the collected data. A total of 45 questionnaires were returned by the respondents representing a response rate of 81.8%.

Descriptive statistics was used to determine the relationship between the study variables while regression analysis was used in inferential statistics involving the determination of correlation and multiple linear regression analysis to test the hypothesis that were developed in the study. The results are presented in the next section.

RESULTS AND DISCUSSION

Introduction

Results of the study are presented using both descriptive statistics and regression analysis on the relationship between the four study variables.

Diagnostic Tests

Diagnostic tests were done on the collected data to determine validity of the data and hence allow the results of the study to be generalized in their application. These tests included, reliability test, normality test and multi-collinearity test.

Reliability Test

The study used Cronbach's (α) to determine reliability of the study instrument and adopted Cronbach's (α) values of between 0.58 – 0.97 to be suitable. Cronbach (α) result confirms the data can be used to provide reliable deductions on the study variables as advocated by Murphy and Davidshofer (1988). The results are presented in Table 4.1

Table 2.1: Reliability Test

Variable	Cronbach's Alpha (α)	Number of items in Scale
Advanced Manufacturing Technology	0.9	22
Competitive Advantage	0.8	15
Organizational Resources	0.9	17
Organizational Performance	0.9	14
Acceptable values of α for the study are between 0.58 and 0.97		

Source: Study Data (2021)

Normality Test

Shapiro – Wilk (SW) test was used to determine normality of the study variables. Results show that all the study variable were normally distributed. The results are presented in Table 2.2.

Table 2.2: Shapiro-Wilk Test for each Dimension of the Study

VARIABLES	SW
Advanced Manufacturing Technology	0.949
Competitive Advantage	0.980
Organizational Resources	0.980
Organizational Performance of Large Manufacturing Companies in Kenya	0.942

Source: Study data (2021)

Multi-collinearity Test

Multicollinearity relates to a situation whereby the predictors in a study are to a high extent correlated. The test for multicollinearity was undertaken within the framework of Variance Inflation Factor and the results are presented in Table 2.3.

Table 2.3: Multicollinearity Test

Variable	Collinearity Statistics	
	Tolerance	VIF
Competitive Advantage	0.509	1.963
Organizational Resources	0.600	1.668
Advanced Manufacturing Technology	0.653	1.531
a. Dependent Variable: Organizational Performance in Large manufacturing Companies in Kenya		

Source: Study Data (2021)

The threshold for the multicollinearity test was 5 and the results in Table 4.3 indicate that all the predictors had VIF values below 2 indicating the absence of high collinearity level among the predictor variables.

Hypothesis Testing

The study sought to establish the joint effect of AMT, Competitive advantage and organizational resources on performance of large manufacturing companies in Kenya by testing the following hypothesis:
H1: There is a significant joint effect of advanced manufacturing technology, competitive advantage and, organizational resources on performance of large manufacturing companies in Kenya.
This hypothesis was tested based on the output from both simple and multiple linear regression analysis where the p-value method was used. The criterion for the hypothesis test was to reject the hypothesis if the p-value obtained is not significant compared to the threshold value (χ = 0.05). Results of the regression analysis is presented in Table 2.4.

Table 2.4: Regression Analysis Results

	Variable	R	R^2	ANOVA Summary (Regression)		Regression Coefficients			
		R	R^2	F	Sig		Beta	t	Sig
Model 1	AMT	.565[a]	0.319	19.662	.000[b]	Constant		13.677	0.000
						AMT	0.565	4.434	0.000
Model 2	AMT, Competitive Advantage	.623[a]	0.388	13.017	.000[b]	Constant		4.776	0.000
						AMT	0.380	2.547	0.015
						CA	0.322	2.158	0.037
Model 3	AMT, Organizational Resources	.698[a]	0.487	19.429	.000[b]	Constant		4.876	0.000
						AMT	0.353	2.802	0.008
						OR	0.461	3.66	0.001
Model 4	AMT, Competitive Advantage, Organizational Resources	.701[a]	0.492	12.903	.000[b]	Constant		3.752	0.001
						AMT	0.316	2.266	0.029
						CA	0.101	0.640	0.526
						OR	0.414	2.853	0.007

a. Dependent Variable: Organizational Performance in Large manufacturing Companies in Kenya

Source: Study Data (2021)

Model 1: Regression of AMT on Organizational performance

Model 2: Regression of AMT and Competitive advantage on Organizational performance

Model 3: Regression of AMT and Organizational resources on Organizational performance

Model 4: Multiple Regression of AMT, Competitive advantage and organizational resources on organizational performance

The results from the multiple regression model 4 (Table 2.4) on the joint effect of AMT, Competitive advantage, Organizational resources and performance of large manufacturing companies in Kenya shows a very strong relationship among the four variables in the study (R=0.701). Results from the multiple regression model summary show the joint effect of AMT Competitive advantage and Organizational resources accounts for 49.2% of variations in Performance of large manufacturing companies in Kenya (R2= 0.492). The ANOVA results showing a significant F-ratio (F= 12.903, p <.005) confirms the suitability of using the multiple regression model on the joint effect in the study.

Further, using the standardized coefficients and ANOVA results (model 4) in Table 2.4, the results show that AMT statistically predicts the value of performance of large manufacturing companies in Kenya in the presence of competitive advantage and organizational resources at a confidence level of 95% (β = .316, t = 2.266, p< .05). This suggests that one unit of increase in AMT in the presence of competitive advantage and organizational resources increases performance of large manufacturing companies in Kenya by 31.6%.

The results also show that competitive advantage is not statistically significant in predicting the value of performance of large manufacturing companies in Kenya in the presence of AMT and organizational resources at a confidence level of 95% (β = .101, t = 2.266, p>.05). Despite competitive advantage not being statistically significant in predicting the value of performance in the presence of AMT, the results show that a unit increase in competitive advantage has the effect of increasing the effectiveness of AMT in manufacturing operations by 10.1%.

Further, the results show that organizational resources statistically predict the value of performance of large manufacturing companies in Kenya in the presence of AMT and competitive advantage at a confidence level of 95% (β = .415, t = 2.266, p< .05). This suggests that one unit of increase in organizational resources in the presence of AMT and competitive advantage increases performance of large manufacturing companies in Kenya by 41.5%. Arising from these results, we fail to reject the hypothesis developed in the study (H1) that there is a significant joint effect of AMT, Competitive advantage, Organizational resources on performance of large manufacturing companies in Kenya.

Results in Table 2.4 confirm the joint effect of the three variables in the study, AMT, competitive advantage and organizational resources to be greater than the individual effects of AMT on performance of large manufacturing companies in Kenya. In particular a) AMT alone explained 31.9% of performance (Model 1), b) Joint effect of AMT and Competitive advantage explained 38.8% of performance (Model 2), c) Joint effect of AMT and Organizational resources explained 48.7% of performance (Model 3) and d) Joint effect of AMT, Competitive advantage and Organizational resources explained 49.2% of performance. This finding reveals a positive synergy on the relationship between the three variables and performance of large manufacturing companies in Kenya.

Discussion of Results

The results from this study demonstrated that there is a significant joint effect of AMT, Competitive advantage and organizational resources on performance of large manufacturing companies in Kenya. This result supports the finding by Leonidou, Palihawadana, and Theodosiou, (2011) that the joint effect of strategy, competitive advantage and organizational resources has a positive impact on performance. The synergy from these three variables allows companies to meet their customer needs and wants. These results suggest that organizations that correctly implement AMT in their operations, will deliver better performance compared to those that fail to correctly adopt AMT in their operations (Musebe et.al, 2022).

According to Chen and Small (1994), some manufacturing companies that have adopted AMT in their production systems did not realize the expected benefits. The results from this study encourage managers to identify the correct AMT to fit their manufacturing strategy to fully realize the expected results. In the current turbulent manufacturing environment where manufacturing companies have to continuously review their product and manufacturing strategy, aligning the type of AMT to adopt to the existing internal and external environments, allows optimization of manufacturing processes and capabilities for manufacturing existing products. Therefore, making wrong investments in AMT can be risky and become expensive leading to adverse experiences on performance.

Competitive advantage was not statistically significant in predicting the value of performance of large manufacturing companies in Kenya in the presence of AMT and organizational resources. This finding confirms the concept of generic competitive strategies as espoused by Corsten and Will (1993) and Musebe et.al (2022), in which AMT supports both cost leadership and differentiation strategies which are assumed to be generally incompatible. Corsten and Will (1993) suggested simultaneity to explain this observation that is divergent to the generally accepted generic competitive strategies. Harris (2012) recognized AMT as an important and special organizational resource, that provides manufacturing companies with the ability to implement both cost leadership and differentiation manufacturing strategies. The finding of this study is in agreement with the classification of AMT as a special organizational resource and emanating from the resource-based view of strategy, it is strategic resources that lead to competitive advantage.

Further, the results also indicate that 50.8% of performance in large manufacturing companies in Kenya is accounted for by other factors that were not considered in this study. According to Shala, Prebreza and Ramosaj (2021), the contingency approach is based on the theory that effectiveness is contingent, or dependent, upon the interplay between different variables and specific situations. Therefore, this finding confirms the contingency approach and theory of management in which the joint effect of AMT, competitive advantage and organizational resources on performance of manufacturing companies does not account for 100% of performance, but other factors like the size of the company, employee competencies, manufacturing process and environment, also contribute towards performance. In other words, manufacturing companies need to choose the type of AMT to adopt depending on their manufacturing strategy and resources they own.

The study findings on the effect of the three variables in the study on performance supports other studies as well. Tracey, Vonderembse and Lim, (1998); Abungu, Maingi and Ombara (2016); Nyori and Ogola (2015), found a positive and significant relationship between the joint effect of AMT, organizational capabilities, competitive advantage and performance of organizations. Empirical results from the study by Tracey, Vonderembse and Lim, (1998) show that competitive capabilities developed through AMT and resources owned by manufacturing companies lead to high levels of performance as measured by customer satisfaction and marketing performance. Customer satisfaction provides feedback to manufacturing companies on product quality and price acceptance by consumers. Employee retention rates have also been found to increase with adoption of AMT in the production process. Organizations need to retain staff to develop and entrench organizational capabilities, which form part of the intangible organizational resources. Staff retention contributes immensely to skills and organizational memory retention.

CONCLUSIONS AND RECOMMENDATIONS

The study sought to determine the joint effect of AMT, Competitive advantage and organizational resources on performance of large manufacturing companies in Kenya. The study developed four hypotheses that were tested using data collected from 55 large manufacturing companies in Kenya. The study employed both simple and multiple linear regression to analyze the data. The study concluded that the joint effect of AMT, competitive advantage and organizational resources on performance was more than the individual effect of AMT or any other combination of these variables on performance. Hence, manufacturing companies expect to improve their performance when they own strategic resources and adopt AMT in their operations. The study recommends that manufacturing companies should consider AMT as important and special organization resources and choose appropriate AMT's aligned to their manufacturing strategy.

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