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Review Manuscript

Necessity of Education for Efficient and Sustainable Production and Consumption of Energy in Tanzania

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ABSTRACT

This paper reports the findings of a study that was conducted in Tanzania to grasp how the policies, plans and curricula at different levels of education accommodate knowledge gathered on energy to support the fostering of energy education. The study interrogated what necessitates the inclusion of energy education into the curricula in Tanzania. Subscribing to a qualitative approach, the study employed a desk research method to review curricula and other documents guiding secondary and university level education in the country. The study found out that heightening people's consumption of energy for domestic and industrial purposes constituted the main issue that necessitates the provision of energy education. Collected data further show that, the Tanzanian curricula targets giving the people knowledge and awareness for safety and how to optimise the use of energy sources, both effectively and efficiently. Moreover, energy education is essentially due to threats of depletion, discovery of new sources of energy, and the need for skilled workers. Such education is also necessary to address the need for expertise and technological advancements in production and consumption methods. The threat of environmental degradation and global warming also make it necessary that people become energy literate. In some cases, energy education aims to meet the investors' needs and provide general knowledge in addition to serving diplomatic purposes. Overall, the study found out that energy education is essential for ensuring the country has sustained energy supply and use, while meeting the needs of the population, and fostering economic growth.

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INTRODUCTION

The grounds upon which education policymakers, curriculum developers, and programme designers decide to include a certain component into the policies, curricula, and education programmes, respectively, may vary from general to specific circumstances. An understanding of such reasons is not only important for curriculum developers but also to learners who deserve to be well-informed about why they have to learn about a certain subject. Recently, energy has attracted the attention of curriculum developers in many countries including Tanzania (the focal point of this paper), hence the inclusion of energy education into programmes and courses for different levels of the country's education.

Literature has shown that many countries from time to time pay attention to energy education for diversified reasons. According to Petrock (1982), the objectives of such education include enabling people to understand the nature and importance of energy; providing them with information on the changing supply and demand factors for various energy sources; preparing people to consider the local, regional, national and international implications of different energy sources; providing information on conservation; preparing people to make personal and societal decisions to energy supply and disruption; and preparing people for energy-related careers and for them to become energy conscious in other career fields. Moreover, energy education is important in schools. As Hofman and Miller (1980) have aptly argued, to teach about energy with enthusiasm and effectiveness, teachers need to be energy literate, implying that in-service training in energy education is crucial and should be instituted for teachers of all grades and disciplines. In essence, awareness, concepts, application, execution, and assessment of technical data as well as energy education resources and techniques should all be an integral part of the perfect teacher-in-service model. Instructors must be knowledgeable about the resources and approaches for energy education available for incorporating into their courses or adapting to local curricula, as Hofman and Miller (1980) have further proffered.

Moreover, Chen, Liu and Chen (2015) and Ntona *et al*. (2015) contend that energy education is vital in enhancing energy literacy and participation in energy-related decisions, hence able to cope with present and future energy needs coupled with the adoption of appropriate lifestyle practices and behaviour. Indubitably, energy education is beneficial for catalysing radical change in human behaviour toward environmentally sound and sustainable orientation to realise sustainable usage of energy. Furthermore, Hoque, Yasin and Sopian (2022) and Özçiçek and Ağpak (2017) assert that energy education has a positive impact on renewable energy deployment, as it assists in ensuring sustainable use of such energy through the introduction of curricula on environmental issues and renewable energy topic. However, such literature (Jennings, 2009; Acikgoz, 2011) have a predominant focus on the provision of renewable energy education, whose purpose stems from the concern on fossil fuel depletion. In the same vein studies in Tanzania (Justo & Mushi, 2020) limit their focus on renewable energy. Thus, little is known regarding why education on energy from diverse sources (beyond renewable energy) has to be provided to the masses. It is also noteworthy that previous studies mention at most five justifications for energy education. There could be more reasons. Besides, paucity remains regarding why energy education has of recent received more emphasis in Tanzania as depicted in recently developed education programmes related to energy.

Until recently, the generation and consumption of energy in Tanzania is mainly depending on biomass particularly firewood and charcoal (88.8%), petroleum (8%), electricity (2%), and renewable energy sources (1.2%). Moreover, according to International Energy Agency - IEA (2019) electricity generation in the country depends on natural gas (50%), hydroelectric power (30%), and liquid fuel (20%). This status is likely to change following the recent discoveries of natural gas in the southern part of the country. In the early 2020s, the recoverable reserves of natural gas in the country amounted to 57 trillion cubic feet (Tcf) (Henstridge, 2020). Such a status has a myriad of implications, including the need for furthering education on energy (see Ndimbwa, 2014). Such anticipated changes might have attracted the recent attention paid to energy education.

This paper attempts to present evidence on why policies, curricula, and programmes at varying levels of education in Tanzania have integrated education for energy production and consumption. Based on the evidence, the paper draws from the Lowan-Trudeau and Fowler's theory of critical energy literacy

(CEL) to argue that the provision of energy education is now imperative in Tanzania, as elsewhere, essentially due to social, economic, diplomatic and environmental reasons. CEL posits that climate crises necessitate critical informed comprehension of energy sources and associated socio-environmental impacts. Thus, the paper emphasises the overriding need for critical understanding of the social, environmental, political and economic challenges, benefits and impacts of various energy sources, transportation and construction technologies (Lowan-Trudeau and Fowler, 2022) through enhanced energy education provision. It also works on the assumption that energy exploitation has the past, the present or projected socio-environmental impacts or benefits for marginalised communities.

METHOD AND MATERIALS

The qualitative study (on which this paper is based) employed desk research to review curricula, policies and plans (using a documentary review guide) guiding the provision of primary, secondary and higher education in Tanzania. It is noteworthy here that, permission was granted by respective authorities to access and use the documents, with acknowledgement to Tanzania Institute of Education (henceforth TIE), University of Dar es Salaam (hereafter UDSM) and University of Dodoma (henceforward UDOM), whereas others are in public domain. Tanzania has an education structure of seven years for primary and four for ordinary secondary education. The two levels constitute the mandatory basic education. Learners at these two levels acquire basic or general knowledge. Tanzania also offers two more years of advanced level of secondary education, followed by two years tertiary training and/or university education whose programmes are mostly for three years with some for four and five years. These latter levels prepare learners for different professions, some of which do touch on issues related to energy education.

Therefore, a total of 18 documents were reviewed. The curricula documents subjected to the review from primary to secondary education are the 2016 primary education curriculum, the 2010 curriculum for advanced level secondary education, as well as the syllabi for Chemistry, Physics and Geography for both ordinary and advanced levels of secondary education. The three subjects were selected because unlike other subjects, they have topics related to energy education. Likewise, although Tanzania has 49 universities as well as other higher learning institutions, most of which have energy-related degree programmes, it was not practically possible to study them all. Thus, only three universities and one institution were selected as a sample. Thus, apart from reviewing four prospectuses from universities, the study also reviewed university curriculum documents, namely the UDSM write-up for establishing the Postgraduate Diploma in Oil and Gas Operations and management (PGD-OGM) programme, the Curriculum for Master of Science in Mineral Processing and Extractive Metallurgy (MSc MP-EM) programme; as well as the UDSM proposal for establishing the Master of Science in Oil and Gas Engineering (M.SC. OGE) programme. From UDOM, the review focused on documents for establishing the Bachelor of Science in Petroleum Engineering, and Master of Science in Petroleum Geosciences programmes.

Other salient documents subjected to review included the 2014 Local Content Policy of Tanzania for Oil and Gas Industry and the 2016 National Skills Development Strategy. These documents convey the justifications of institutions for establishing energy-related education programmes and courses.

Furthermore, the study also used workshop discussions (using focus group discussion guide) with ten academics at the University of Dar es Salaam to seek their views based on their experiences with energy education provision. The purposively selected academics participated in the study because they constituted a multidisciplinary university

team that worked in collaboration with the University of Aberdeen (UK) on developing and improving the cross-cutting issues relating to petroleum research and education. The team members came from engineering, geology, law, economics, geography and education disciplines.

The collected data were processed through the use of NVivo 14 software to generate node and themes. Thus, the data in form of excerpts from documents and verbatim quotations from discussions were then subjected to Thematic Analysis, hence generating diverse reasons for energy education. The excerpts serve as evidential statements in the narrative presentation. To validate the findings, peer debriefing with participants was engaged through seeking their views on the results of the study. Given its qualitative approach, this study does not examine how energy education provision is statistically associated with desired outcomes.

RESULTS AND DISCUSSIONS

Energy Education in Primary and Ordinary Secondary Education in Tanzania

In Tanzania, there is no specific energy education subject at the primary and secondary education levels, but there are topics scattered in the curricula of several subjects that lay the base for building knowledge on energy at the higher levels. These subjects include General Science, Geography, Physics, and Chemistry. For primary schools in Tanzania, classes 3 and 4 pupils learn about electrical, light and heat energy in science subject. In this regard, a statement from a curriculum document that reads in part:

> This curriculum has taken into consideration several national and international declarations such as the following: ... to ensure [the] availability of safe energy, clean and safe water, as well as environmental cleanness for all people …Specific competence ... identifying diverse types of energy and their use (*MoEST, 2016 primary education curriculum for standard III – VI, pp.2-3and pp.15 -16*)

For ordinary secondary schools in the country, students in form One to Four learn in Geography about energy sources, natural gas, the gas impact on Tanzania in various topics and sub-topics almost in each class level. In form one for instance, one of the topics in Geography is about the solar system whose sub-topics include solar energy. The specific objective of the sub-topic states that students should "explain how the use of solar energy promotes environmental conservation" (TIE, 2016, pp. 5). The statement hints at why energy education provision is crucial for conserving the environment.

Additionally, Geography subject for Form Two has a topic on sustainable use of power and energy resources, with a sub-topic on methods for acquiring or extracting power and energy. Under this sub-topic, the specific objective is to enable students to "describe the origin of different types of energy and power sources and identify the type of energy and power sources" (TIE, 2016, pp. 65). In Form Three, Geography students learn about how to analyse rock types by looking at the mode of formation and their economic importance covered under the topic "Structure of the earth" (TIE, 2016, pp. 75). Moreover, Form Four students learn about how environmental issues are related to energy under the topic of environmental management, and the sub-topic on environmental pollution, whose specific objective states that students should "analyse the causes, extent and effects of pollution and waste management" (TIE, 2016, p. 124). Implicitly, energy education is a vital cog in conserving the environment.

Moreover, the Tanzania syllabus for Form Two chemistry subject has a topic on Fuel and Energy, and a sub-topic on renewable energy (Biogas) whose specific objective requires students to "explain the working mechanism of a biogas plant" (TIE, 2017a, pp.37). In the same subject, Form Four students learn about organic chemistry under the sub-topic of introduction to organic chemistry. The fourth objective of the sub-topic states that students should "describe the fractional distillation of

crude oil" (TIE, 2017a, pp.107). Moreover, under another topic on Aquatic Pollution, a student has to "identify human activities which cause water pollution" (TIE, 2017a, pp.126) whereas among other human activities that cause water pollution is the exploration and extraction of natural gases. Thus, even in chemistry, the environmental concerns are attached to education about energy types and sources.

In Physics, which is on one of the science subjects in the country's secondary education curriculum, energy-related issues fall under different topics and sub-topics of its syllabus across the classes and levels. In the Form Two syllabuses, the ninth topic is on sustainable energy sources, with sub-topics on water energy, solar energy, wind energy, sea wave energy and geothermal energy (TIE, 2017c). However, the topic does not have an explicitly stated sub-topic on natural gas as a source of energy for students to study at this level.

The Form Three syllabus also has topics on reflection and refraction of light as well as Thermal expansion with a sub-topic on thermal energy, which requires students to "state the sources of thermal energy in everyday life" (TIE, 2017c, pp. 94). The other sources include gas. In Form Four, students learn more about energy education under a topic about Radioactivity, and a sub-topic on nuclear fission and fusion, with one of the specific objectives requiring students to "explain the nuclear fission and fusion" (TIE, 2017c, pp. 139). These topics help learners to grasp and have clear understanding of nuclear energy as one of the sources of energy. Furthermore, under a topic on Geophysics and a sub-topic titled Structure and Composition of the Earth that induce students to "describe the composition of the layers of the earth" (TIE, 2017c, pp. 149) and, hence, learn about layers that have a deposit of fossil fuels.

Energy Education for Advanced Secondary Education in Tanzania

For advanced secondary education chemistry, students acquire energy education under a Form Five topic on gases, with a sub-topic on Kinetic theory of gases, which require students to "describe the characteristics of a gas as influenced by pressure, volume and temperature" (TIE, 2017b, pp. 8). Likewise, in Form Six, under a topic on Environmental chemistry, and a sub-topic about Pollution, through the second specific objective, students ought to "describe aquatic terrestrial and aerial pollution and their intervention measures" (TIE, 2017b, pp. 69). Hence, the advanced secondary education also connects the environment and energy.

Moreover, advanced secondary level students learn through Physics subject about Properties of Matter in form five, through a sub-topic on kinetic theory of gases and a specific objective that targets enabling students to "interpret the assumptions of the kinetic theory of gases" (TIE, 2017d, pp.17). Furthermore, they learn about heat and thermodynamics, under the topic Heat, and sub-topic on First law of thermodynamics, whose specific objective states that students should *"identify specific heat capacity of gases"* (TIE, 2017d, pp. 21). Form Six also has topics and sub-topics on energy education—atomic physics, nuclear physics, and environmental physics. Under these topics and associated sub-topics, learners determine the number of available reserves and methods of extracting wind, geothermal and wave energy (TIE, 2017d): "This competence will enable learners to develop the ability to... participate appropriately in harnessing resources and energy for mutual benefit" (TIE, 2010). The curriculum statement shows that learning about energy at the advanced level of secondary education exposes learners to knowledge that would make them capable of taping into and using energy in a beneficial and efficient manner.

Indeed, these subjects and topics are connected to energy education because physics and chemistry principles, along with geographical knowledge, vehicles for harnessing energy sources. Other subjects can also foster energy education (History, English, economics, etc.) because of its multidimensional and multidisciplinary nature (Bouman and Petrock, 1981).

Energy education in Tanzania's Higher Education Institutions

The heightened attention paid to energy education in higher learning institutions, particularly when it comes to oil and gas is related to new discoveries of gas deposits in two regions of Mtwara and Lindi (Songosongo area). Currently, such education is offered at the University of Dar es Salaam (UDSM), the University of Dodoma (UDOM), Nelson Mandela African Institution of Science and Technology in Arusha (NM-AIST), and the Mineral Resource Institute (MRI), as well as several tertiary institutions (TCU, 2023).

At the UDSM, three petroleum-related undergraduate programmes on offer are B.Sc. in Petroleum Geology, Bachelor of Science (B.Sc.) in Petroleum Engineering by the School of Mines and Geo- Sciences (SoMG), and B.Sc. in Petroleum Chemistry by the Chemistry Department of CONAS (UDSM, 2023a). The university also offers postgraduate programmes in Petroleum, such as Master of Science (M.Sc.) in Oil and Gas Technology under the College of Engineering and Technology (CoET), M.Sc. in Petroleum Engineering by the Department of Chemical and Mining Engineering under CoET, Master of Finance and Accounting in Oil and Gas under the University of Dar es Salaam Business School (UDBS), MSc. in Petroleum Geology by the Department of Geology of CoNAS, Master of Arts in applied Economics with Energy Economics and Petroleum Economics by the Department of Economic under the UDSM School of Economics and Master of Laws (LLM) Oil and Gas under the UDSM School of Law (UDSoL) (UDSM, 2023b).

From the 2012/2013 academic year onwards, UDOM started offering a B.Sc. in Petroleum Engineering under the College of Earth Sciences, which also offers an M.Sc. in Petroleum Geology, M.Sc. in Petroleum Reservoir Engineering, and M.Sc. in Petroleum Production Engineering (UDOM, 2023).

Likewise, the Nelson Mandela African Institute of Science and Technology (NM-AIST) in Arusha is embarking on offering a petroleum-related post-graduate degree (NM-AIST, 2023). Tertiary institutions offering the Ordinary Diploma in Petroleum Geo-science include the Mineral Resource Institute (MRI) and has been doing so since the 2012/13 academic year. MRI also has programmes such as Oil and Gas Management and Petroleum Geology in its curriculum. Likewise, the Earth Sciences Institute of Shinyanga (ESIS), a private college, offers training in Exploration and Mining Geology, Geology of Oil and Gas, and Diploma in Petroleum Geology.

Necessity of energy education in Tanzania

People's consumption of energy. Energy education is necessitated by a range of issues such as people's consumption of energy, for domestic purposes and industrial use. People therefore need knowledge and awareness for safety, and on how to use the sources of energy, both effectively and efficiently. In Tanzania, for instance, following the discovery and exploitation of natural gas in the country, more energy development plans are afoot with projects being implemented to connect the gas supply to residential houses in major cities such as Dar es Salaam for domestic use. Explaining this development, one of the research participants said:

> From a sustainability point-of-view, energy education is important so that people can appreciate both the good and the bad about the sources of energy they use. For example, oil is economically a good source of energy, but its means of production can have severe negative environmental impact, which can harm humans and other living things. For the poor in rural areas, their main source of energy for cooking tends to be firewood. Unless there are forests where the wood is sustainably harvested for firewood, this can lead to deforestation, which has other negative consequences. Education on other sources of energy such as solar, which is abundant in Tanzania, may gradually shift people to sustainable sources of energy, albeit the costs of appliances for solar energy may be

expensive. So, there is value in energy education in terms of sensitizing people about good and bad sources of energy and support people towards sustainable energy use.

Depletion concerns. Energy education is also crucial amidst the fear of depletion (related to the demand and supply objective) primarily because conventional sources of energy such as charcoal and fossil fuel pose numerous challenges such as deforestation and depletion of non-renewable fuel deposits (see Shafiee & Topal, 2009). Students are, therefore, learning about energy to be in position to use the sources in a sustainable manner. Such purpose is reflected, for example, in the competencies that a Form Two secondary school student ought to develop by demonstrating "… the ability to manage and use power and energy resources sustainably" (Secondary education Geography Syllabus, pp. 27). Students should also "have the ability to …use fuels efficiently and sustainability with environmental consideration" (Secondary education Chemistry syllabus, pp. 31).

New sources discovery. Energy education also commands attention when discoveries of new or more sources of energy emerge. In this regard, a justification statement for launching a degree programme related to energy at the University of Dar es Salaam reads in part: "The discoveries of gas reserves in Tanzania estimated at 57 Tcf and recent development in the oil and gas sector in the country demands a strong local workforce" (*Proposal for Establishment of Master of Science in Oil and Gas Engineering* (*M.Sc. OGE*) *Programme, p.3*). Similarly, another UDSM document states:

> In Tanzania, exploration for oil and gas goes back to the 1950s. The first natural gas discovery was made on the Songosongo Island in 1974, which was followed by another gas discovery in the Mnazi Bay in 1982. From 2000s, Tanzania has witnessed further exploration and discoveries of significant quantities of natural gas both on- and off-shore, accounting to 57.25 trillion Cubic Feet (TCF) as per early 2018. These discoveries have prompted renewal and extensive exploration activities across the on- and offshore Tanzania by Tanzania Petroleum Development Corporation (TPDC), attracting other numerous international oil exploration companies (e.g. Statoil/ExxonMobil, Shell Tanzania, Ophir Energy, SWALA, Schlumberger, PANAFRICAN Energy, Halliburton, Petrobras, Maurel and Prom, Ndovu/Aminex, Petrodel) to investing in Tanzania" (*Proposal for establishment of postgraduate diploma in oil and gas operations and management (PGD-OGM) programme of the University of Dar es Salaam, 2019, p.6*).

The statement sounds as though if it was not for the discovery of gas deposits in Tanzania, it could have been unnecessary to offer a degree programme in oil and gas. Such outlook has some faults because higher education is international, but for better teaching about such energy source there has to be nearby sites for instance for practical learning. Similarly, at UDOM, one of the documents justifies the establishment of energy degree programmes thusly:

> The oil and gas industry in Tanzania is expected to grow significantly in the coming ten years and hence contributing positively to the socio-economic development of the Country. Prospects of getting crude oil along the cost of the Indian Ocean have been confirmed by many exploration companies. The biggest discoveries have been the Songosongo and the Mnazi Bay gas fields with an estimate of 2.0 and 1.0 trillion cubic feet of gas reserve, respectively. According to Tanzania Petroleum Development Corporation (TPDC) exploration wells that have been reported to have oil-shows include Pemba-5, Mandawa-7, Mafia-1 and Mita Gama-1. Other prospects for oil and gas have been reported in Mafia Island basin, Kisangire, Selous, Nyuni (Ruvuma) and Kimbiji (Tanga), Deep

> Sea (Blocks 1-12), North and South of Lake Tanganyika (*UDOM Bachelor of Science in Petroleum Engineering programme*).

Discovery of oil and gas has also influenced Tanzania's plans for skills development, with the onus on institutions to develop the human resource capacity required in the upcoming sector, as one of the plans read:

> … train nine hundred Tanzanians (450 artisans, 300 technicians, and 150 university graduates) in oil and gas related skills by 2020, by providing capacity building and specialised infrastructure for oil and gas skills training at selected training institutions (*National Skills Development Strategy, 2016*, pp. xix).

Diversification of energy sources. Energy education in the country also stems from the need to diversify its sources to ensure a reliable and wide-range supply to the consumers. During the workshop discussion, one of the participants in this study said:

> Tanzania is endowed with diverse energy sources. Most of these energy resources currently are untapped. For example, the potential on hydropower stands at around 4.7GW, whereas in the oil and gas its around 2,744MW and coal is 3,800 MW. The geothermal potential is around 650 MW where the solar is -the potential for grid connected solar PV is estimated to amount to 800MW and the wind power potential from the current discovered sites in Kititimo in Singida region and Makambako in Njombe region stands at around 2.5 to 3MW with blades of about 50 meters in length. Most of these are untapped and need not only capital but also education on why it is important to harness more energy resources to improve the energy mix in Tanzania. The current general energy mix is primary energy supply is biomass; petroleum products; electricity and coal and other renewable energy Sources. Most of the energy is delivered form biomass and this, at 80% is consumed in rural areas. The energy consumption ladder is biased towards the rural areas and towards the traditional fuels with the rural-urban comparison. In addition, the energy access is still incredibly low in Tanzania trailing around 33% in 2023. Then, given the growing energy demand in Tanzania due to its target plan for industrialisation, it is particularly important to educate our coming generation on the energy potential we are having as a country and most importantly how to improve the energy mix.

The participant's observation is in line with claims in the literature that energy is indeed needed in Tanzania for industrialisation (Kiiza, *et al.*, 2023). Implicitly, Tanzania's endowment in the energy sector necessitates the provision of education to Tanzanians for them to benefit from the gift of nature that ranges from water bodies, fossil fuel, and wind power to biomass.

Economic purposes. The Tanzania government would also like to educate the populace for economic gains that can be accrued from energy supply and utilisation. As one of the documents reviewed states:

> Currently, the oil and gas sector is one of the new and fast-growing sectors in Tanzania. To fully realise the economic, Government industrialisation agenda and other benefits of this potentially very promising sector the Government is making efforts on several fronts, including policy, legal and institutional frameworks to manage the industry and associated geo-science operations more effectively; to develop adequate human resources (capacity building), fill up the local content gap through introduction of different courses and programmes in several universities related to oil and gas and providing overseas scholarships in oil and gas related fields for Tanzanians (*Proposal for establishment of postgraduate diploma in oil and gas operations and management [PGD-OGM] programme of the University of Dar es Salaam, 2019, p.6*) .

The statement reveals that university programmes are responsive to national economic needs and are supporting initiatives related to making potential economic sectors grow and create jobs for the workforce. Similarly, another statement reveals;

> [The] Marshal Plan refers to the educational plan in oil and gas related subjects prepared to bridge the observed gaps for fast and successful operations in the oil and gas industry (*Local Content Policy of Tanzania for Oil and Gas Industry - 2014*)

The statement provides a clue on the economic purpose of energy education that the country needs to harness. More evidence form documents are that;

> It is therefore evident that the oil and gas industry in Tanzania will very soon be one of the key contributors to the Country's Gross Domestic Products (GDP). The industry will contribute substantially to Government revenue through taxes (such as income tax, royalty and withholding taxes on dividends) and indirect taxes. In addition, the industry has other social economic benefits such as energy security in various sectors such as Transport, Industry, domestic, etc. Also, most of the oil and gas products are used as feed stocks for manufacturing of many products such as lubricants, asphalt, bitumen, fertilizer, pharmaceuticals, cosmetics, etc. Manufacturing of these products and other related products in the Country will widen up exploitation of the oil and gas industry and hence increasing Government revenue and subsequently improving welfare of Tanzanian people (*UDOM Bachelor of Science in Petroleum Engineering programme*).

One of the participants in this study further supported the economic purpose of energy education as follows:

> Energy education is particularly important in the African context for several reasons. First, it can contribute to addressing the exiting poor energy supply by promoting awareness of sustainable energy sources and efficient consumption practices. Second, it supports economic development by fostering a skilled workforce in the energy sector. Third, understanding energy can empower communities to make informed decisions about energy access, leading to improved living standards and enhanced resilience to energy-related challenges while scratching their brains. Overall, energy education plays an important role in driving sustainable development and addressing pressing issues in the African context.

Skilled workforce and expertise. The need for specialised expertise and skilled workers in Tanzania is another factor that necessitates energy education. When a country realises the energy sector is rapidly growing in an irreversible course, the need for more human resource to run the sector becomes inevitable, hence the overriding necessity to educate individuals in the area. During a discussion with the academics from the UDSM, one of them said:

> Oil and gas education is crucial in Tanzania to harness its rich natural resources responsibly. Specialized training ensures skilled professionals, fostering sustainable development, maximising economic benefits, and minimizing environmental impact. It is a strategic investment in Tanzania's future.

Furthermore, the University of Dar es Salaam justifies its MSc in Oil and Gas Engineering programme by stating that:

> Sectorial activities covering subsea mechanical systems, processing equipment, transport pipelines, supply chain and logistics, utilization of these resources in power plants and associated environmental issues offer numerous employment and entrepreneurial opportunities. Participation of the local population in these activities has been hindered by lack of requisite academic qualifications due to low training capacity of the local institutions in the oil and gas sector. … Therefore, there is an urgent need for training in oil and gas engineering and

> technology at a national and regional level in response to the high demand of skilled human resources (*Proposal for the establishment of Master of Science in Oil and Gas Engineering* (*M.Sc. OGE*) *programme,* pp. 3)

Policies also stipulate the training role of academic and research institutions amidst the overriding need for experts. One of these policies describe this scenario as follows:

> Academic and Research Institutions are important for development of the oil and gas industry. Development of the industry has increased demand for knowledge and skills in Tanzania. In order to meet the demand, the Government has taken measures to introduce and expand training in relevant fields in the oil and gas industry. These institutions will work with [the] Government and IOCs to promote education, training and research in the oil and gas industry, recruitment and retention of the human resources required in the industry (*Local Content Policy of Tanzania for Oil and Gas Industry - 2014 pp. 30 - 31*).

The statement also spells out the economic purpose of the endeavours and the need for energy experts in the country. Likewise, UDOM envisions:

> The sustainable investment and harnessing of oil and gas resources needs among other things, a large pool of trained technical staff in this discipline. Hence training of staff in this area is strategically very important for the benefit of the country and the industry. This program is of great importance in addressing the potential need of petroleum engineers; and it is in line with the University of Dodoma vision namely, 'to become a centre of excellence and valued member of the global academic community, offering comprehensive education in diversified academic programmes geared towards intellectual transformation, giving knowledge needed to competently and competitively solve development challenges. The School of Mines and Petroleum is very proud of hosting this program and the school will work towards maintaining its educational standards same as with the internationally well-known Petroleum Engineering training (*UDOM Bachelor of Science in Petroleum Engineering programme*).
>
> …This programme is designed to provide students with a broad background for a geology career and thus to produce highly qualified petroleum geoscientist to suit the fast-growing petroleum exploration. This two-year program is focused on state of the art of geological skills on field mapping, geophysical survey, geochemical survey, mineralogy and petrographic studies and remote sensing studies (*UDOM Master of Science in Petroleum Geosciences programme*)

Technological advancement. Inevitably, the emerging innovations in production and consumption coupled with technological advancement require an up-scaling of the provision of education. In Tanzania, for instance, energy education can facilitate the consumers' adoption and accessing of efficient energy-saving charcoal stoves currently in the vogue amidst spiralling costs for conventional sources of energy. One of the participants said:

> With proper education, Tanzanians can better adopt new technologies and innovations in the energy sector, from household solar panels to large-scale renewable energy projects. Lastly, educated citizens can participate more effectively in policy-making processes and advocate for effective energy policies, leading to more democratic and inclusive decision-making in the energy sector. In short, energy education in Tanzania is vital for sustainable development, environmental conservation, and overall societal wellbeing.

The statement tells among other things that energy education may trigger much desired developmental issues such as innovation,

inclusivity and green skills. Likewise, another participant said:

> It is especially important indeed for any process or technology you want to implement to think about energy, environment and the process or technology itself, its kind like a triangle. Food sector uses about 30 percent of the energy used in the world. Looking in this one should focus on the energy aspect before implementing any process or technology which requires energy. One should do feasibility study to assess kind of energy to be implemented! You do not dry mangos and then you use freeze drying technology which is among the best but expensive techniques.

Indeed, for improved technology and effective energy policies to adapt renewable energy projects to take root in Tanzania there is a need for concerted efforts aimed at scaling up energy education not only in the various levels of the education ladder but also at the grassroots.

Global warming and environmental issues. Energy education in Tanzania has received an even greater sense of urgency amidst raising threats of environmental degradation and global warming. Deforestation, hydrocarbon waste, greenhouse effect, and nuclear waste disposal are some of the sources of grave concern. In this regard, people need energy education to build their capacity in addressing such environmental issues. For instance, secondary school students learn through Geography to "… explain how the use of solar energy promotes environmental conservation. Teacher to guide students to discuss the relationship between uses of solar energy and environmental conservation (*secondary education Geography syllabus, p.5*). In line with that, one participant said:

> Energy education helps to make best option on the environment friendly energy sources. For example, currently the world is trying to reduce/eliminate the use of petroleum hence energy education will foster those changes especially in Tanzania as we are still in the failure to eliminate the use of charcoal and firewood while we are rich in natural gas.

Indeed, energy education is essential in ensuring environmental conservation by investing in renewable energy sources. Energy education is crucial in Tanzania for several reasons. It raises awareness on renewable energy sources such as solar, wind, and hydroelectric power, which are abundant in Tanzania. This knowledge can lead to more sustainable and environmentally-friendly energy consumption, since consumers will have an understanding of the impacts of various energy sources on the environment.

Meeting investors' requirement. In some cases, energy education is provided to meet investors' requirement. This is as indicated for example, in one of the degree programmes justifying documents:

> Oil and gas industry in Tanzania is taking off, and it is expected to grow very fast as the prospective resource areas mentioned above come to reality. In addition, currently there many companies in the Country dealing with oil and gas exploration, and others dealing with transportation, marketing and selling of petroleum and petroleum products (*UDOM Bachelor of Science in Petroleum Engineering programme*)

Such a statement gives a clue that investors are increasing in Tanzania in the energy sector, and therefore related degrees have to be offered to Tanzanians (and other nationals) to prepare the human resource required in such growing investment.

General knowledge. Provision of general basic knowledge is yet another justification for energy education intervention. This is as reflected for instance, in the primary education curricula, since one of the competences that a learner has to develop is recognition of different types of energy and their uses. One of the participants explained the need for general knowledge on energy and its essence as follows:

> Energy education is highly required in our communities mainly for the following

reasons: One, it helps to identify the various sources of energy available within and contribute in protecting them. Two, it stimulates the proper utilisation of available energy sources for majority benefits example in Tanzania although we have a lot of energy sources like coal, natural gas, water, wind, biogas but only one source used to produce electricity that leads to shortage of electricity. Three, it will boost accountability in the sense that, community member will be in the good position to challenge the political leaders as they will be knowledgeable om the energy sources available and how they can be utilized for majority benefits than exported.

Diplomatic purposes. Apparently, energy education also serves diplomatic purposes because some bilateral and multilateral cooperation initiatives revolve around the issue of such education. For example, as pointed out by participants in this study, Tanzania receives considerable assistance such as laboratory equipment, guest lecturers and scholarships for students as well as collaborative programmes from countries such as Norway, United Kingdom, Netherlands, and China on energy-related education.

Women emancipation. Moreover, energy education is provided in Tanzania with expectations that it would contribute significantly towards women emancipation. In many cases women bear the burden of collecting faggots and other materials essential for meeting domestic energy needs in their households. In this regard, Tanzania's secondary education curriculum for Geography states:

> Students should … explain how solar energy may contribute to [the emancipation of women. … by using diagrams showing different uses of solar energy teacher to guide students discuss how solar energy contributes to emancipation of women (*Secondary education Geography syllabus, pp. 5*)

Further, knowledge on energy includes understanding health and safety aspects related to energy production and consumption. Such knowledge is pertinent particularly in rural areas where the use of traditional biomass is prevalent. This awareness can lead to not only to the efficient use of energy sources available but also improved health outcomes for the rural dwellers. Energy education do empower women and marginalised communities, who often suffer the most from adverse effects of inefficient energy systems. In other words, educating these groups on alternative sources of energy and their efficient use can lead to improved living conditions and significantly contribute to their greater autonomy.

DISCUSSION

Energy education permeates various levels of Tanzania's education system. Although there are no specific energy education subjects in primary and secondary schools, there are numerous topics in the official curricula related to fostering energy knowledge, hence affirming the essentiality of such education particularly for environmental reasons and sustainability agenda. Such embedment of energy education into the curricula is also a recommended practice in other African countries such as Uganda (Sendegeya *et al*., 2006) for conservation and environmental sustainability. Asian countries are also providing energy education for similar reasons. In Malaysia for example, Hogue *et al*., (2022) established the need for energy education to equip learners with knowledge and skills pertaining to sustainable use of renewable energy in addition to informing them about environmental conservation. What the current study adds, is a coverage of diverse reasons for energy education and transcending the focus on renewable energy. Such education can influence sustainable energy use while accruing social, economic and environmental gains through the adoption of appropriate lifestyle practices and behaviours.

As depicted by the findings, within the education system of Tanzania, energy education strives to make learners capable of using energy in a beneficial manner. Such agrees with Hendrickson *et al.*, (2015) argument that energy education should prepare people to consider the implications of different energy sources and, hence, make appropriate decisions on how to utilise equitably and sustainably. Besides, this study findings are consistent with Chen et al. (2015), who reported that energy education should improve students' literacy and engagement in energy-related decisions.

The findings are by-and-large congruent with the theory of critical energy literacy (Lowan-Trudeau and Fowler, 2022) on energy education providing a critical understanding on the benefits and impacts of energy consumption and production (see Danguche and Taifa, 2023) in socioeconomic and environmental aspects. Impliedly, energy education influences learners to make correct decisions on consuming energy sources while considering the implications of their behaviours in future usage.

As evidenced, the necessity of energy education at higher learning institutions has influenced the establishment of various undergraduate and postgraduate programmes offered by universities in Tanzania because of the overriding need for experts and skilled workers to run various energy sectors following discoveries oil and gas as bountiful energy sources. The study findings therefore concur with Ndimbwa (2014), who resent energy education as essential and pivotal due to natural gas discoveries and, hence, the need to prepare people for energy-related careers. The current study adds that energy education facilitates the generation of a skilled local workforce to fulfil the demands of the newly-discovered energy sources.

Generally, energy education is crucial in the current education system because it not only helps individuals understand the importance of energy sources, but also supports the diversification of sources, technological advancement, serving diplomatic purposes, women emancipation, and more.

CONCLUSION

Overall, energy education is provided for not less than twelve reasons. Specifically, Tanzania needs energy education for the conservation of the environment, and diversifying the sources of energy education for reliable and widening the supply of energy sources in addition to creating awareness on discoveries of new sources of energy. Moreover, the country needs to produce experts and skilled workers to run the energy sector since amidst these new discoveries the country has the responsibility and obligation to develop its expertise largely locally. Tanzania, therefore, needs dynamic clearer and stronger policies, curriculum and programmes on energy education, especially now that oil and gas are potentially a significant sector.

Thus, the study findings are deemed important as they may inform policymakers, curriculum developers, education planners regarding the necessity of ensuring that energy education is provided across all levels of education in Tanzania and beyond. Given the justifications, the society at large needs to embrace energy education even through informal systems. It is recommended that further studies should examine the extent to which the provision of energy education has produced the desired outcomes.

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