Challenges of teaching and learning space dynamics in ever-changing climatic conditions in Secondary schools in Tanzania

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Abstract
The teaching and learning of space dynamics, which basically addresses dynamic content such as weather and climate, presents significant challenges to teachers due to its complexity and ever-changing nature. This study examines the practical experiences of teachers in navigating these challenges within the context of Tanzania. The study employed a mixed-methods research approach, and an embedded mixed research design. To collect data, the study used documentary reviews, semi-structured interviews, and open-ended questionnaires. A sample of 20 geography teachers from seven selected schools in the Dodoma Region participated in the study. The findings reveal that teachers face major constraints such as insufficient teaching resources and inadequate professional training. Moreover, the complexity of the space dynamics and teachers' incompetence impeded the development and assessment of the intended competencies. The study further indicates that teachers and students focus on success in the national examination, at the expenses of practical application of knowledge in real-world contexts. The study concludes that without appropriate interventions, the ability of both students and teachers to effectively contribute to mitigating the adverse impacts of climate change will remain unfulfilled. To enhance the teaching and learning of space dynamics in secondary schools, it is recommended that the government should increase funding for teachers' professional development programs; and provide facilities including digital technologies to support the design and adaptation of teaching materials.

Keywords: *Climate change, space dynamics, competence, teaching and learning*

INTRODUCTION AND BACKGROUND OF THE STUDY

Weather and climate change have a significant effect on both flora and fauna. These include reduced food production, negative impacts on human health, inadequate pasture, and water shortages (Tanzania Meteorological Authority, 2024; United Nations, 2016). The study of space dynamics introduces learners to key competencies related to weather and climate, intending to foster their ability to actively engage in mitigating the negative consequences of climate change on the environment (Ministry of Education and Vocational Training, 2010). In Tanzania, students are expected to develop an understanding of the interrelationship between topography, climate, and natural vegetation (Ministry of Education, Science and Technology, 2023b). Amwata, Tumbo, Mungai, and Radeny (2020) reported that there is a need to create awareness to local farmers on climate and its impact on agriculture and food security. This underscores Tanzania's readiness to prioritize the development of climate change mitigation and adaptive capacity to ensure sustainable development.

Climate change is one of the greatest challenges today that threaten many countries' ability to achieve sustainable development. It causes rise in temperature, sea levels, and ocean acidification, thus endangering the life of living things especially in coastal and low-lying regions (United Nations, 2016). The 2015 United Nations Climate Change Conference (Paris Agreement) emphasized education as a fundamental instrument in advancing global efforts to address climate change (United Nations, 2015). The Sustainable Development Goals (SDGs) for 2025–2030 highlight the pivotal role of education in enhancing public awareness and strengthening institutional capacity for impact reduction, mitigation, adaptation, and early warning systems related to weather and climate change. The global agenda for SDG4-Education aims to eradicate poverty and hunger, safeguard the planet from degradation, and ensure that everyone appreciates a prosperous and fulfilling lives by 2030 (United Nations Educational Scientific and Cultural Organization, 2017).

Tanzania like other African countries, its economy relies on climatic-dependent agriculture, which is more vulnerable to the undesirable impact of weather and climate change (Amwata et al., 2020). Tanzania has recorded an increase in drought and floods causing the destruction of the environment, death of people and animals, thus leading to reduction of agricultural production, food insecurity, malnutrition, and poverty

(Tanzania Meteorological Authority, 2024). Amwata et al. (2020) reported that, most Tanzanians have relatively low weather and climate change resilience and adaptive capabilities. This indicates that education has not been fully tapped to build people's capacity to sustain and mitigate climate change in Tanzania. The introduction of space dynamic topic in Secondary school curriculum is an avenue to develop competences in young people and motivate them to participate actively in the activities that can reduce the adverse impact of climate change on environment.

The Tanzania Meteorological Authority (TMA) predicted that Tanzania will continue to experience adverse impact of climate change on environment (Tanzania Meteorological Authority, 2022). The TMA (2024) reported that heavy rainfall accompanied with widespread floods caused destruction of infrastructure, population displacement, loss of lives, and properties. For instance, the recent tragic mudslide in Hanang-Manyara caused death of 89 people, 139 injuries, and 5600 displacements of people, destruction of 724 houses and 496 acres of farms This is the realization of the TMA (2022) prediction that the adverse impact of climate change in Tanzania and other East African countries may increase in the future. This indicates that peoples' capacity and readiness to participate actively in reducing the adverse impact of weather and climate change is insufficient Thus, teachers in school are required to take part in the action by developing students' knowledge, skills, and abilities to actively mitigate and adapt to climate change.

Climate change education has been a contagious matter worldwide (Amwata et al., 2020; Apollo & Mbah, 2021; Henderson, Long, Berger, Russell, & Drewes, 2017; Kumar, Kumar, Tokas, Lal, & Singal, 2018; Liebhaber, Ramjan, Frick, Mannion, & Keller, 2023; Ochieng & Koske, 2013; Zhao, Pan, Ma, Raza, & Zhou, 2023). The study by Apollo and Mbah (2020) conducted a critical review on the challenges and opportunities of climate change education in East Africa. Zhao, Pan, Ma, Raza, and Zhou, (2023) concentrated on the impact of digital education on tertiary climate change education in China, (Liebhaber et al (2023) concentrated on the developing climate-friendly transformative approach to climate education in Autrian and Germany schools, while that of Ochieng and Koske, (2013 concentrated on the level of students' awareness on climate change in Kenya primary schools. However, there is limited research on the area of teaching and learning space dynamics

i.e. weather and climate in Tanzanian secondary classroom context. This study intended to investigate the practical challenges of teaching and learning of space dynamics in ever-changing climatic conditions in secondary schools in Tanzania. Particularly, it aims to respond to the key research question: What are the challenges associated with teaching and learning strategies, resources and the realization of the intended space dynamic competence in Tanzanian secondary schools?

Constructivism alignment theory can be used to ensure that learners develop the intended competences. Constructivism is an epistemological view which believes that knowledge is developed when the learners are at the heart of the learning process (Ali, 2018). It stands on the belief that efforts should be taken to align learning outcome with the teaching and learning activities, resources and assessment (Loughlin, Lygo-baker, Lindberg-sand, & Loughlin, 2021). Constructivism alignment theory allows learners to engage in individual and group tasks. Since the learning is aligned to a specific learning outcome, teachers and learners are guided to precisely concentrate on learning activities and assessment that can effectively attain the intended learning outcome (Brabrand, 2007). In this sense, the relationship between the teacher and the learner is that of a teacher as a facilitator and the learners an active participant of the teaching and learning process (Zhang, Su, Zeng, & Lam, 2022).

However, studies such as Liu et al,2015 claim that teaching and learning about weather and climate change is constrained by misconceptions from both teachers and learners especially around the areas of the greenhouse effect and ozone layer comprehensively influence atmospheric phenomena. In the same light, research documents corroborate the absence of mitigation strategies, alongside persistent understanding gaps which exist amongst students and teachers with regard to the causes of climate change. (Apollo & Mbah, 2021; Ochieng & Koske, 2013; Silvestri et al., 2012). Additionally, Henderson et al. (2017) reported the presence of knowledge gap among teachers that is associated with a lack of adequate content knowledge. This calls for the need to clearly understand challenges and recommend measures to effectively teaching and learning of space dynamics (weather climate education) in schools.

METHODOLOGY

This study employed a mixed methods research approach to data collection, in which the qualitative approach served as the dominant

method. The study employed an embedded mixed-methods research design, in which quantitative data were incorporated within a predominantly qualitative data to enhance the depth of analysis. Cohen, Manion, and Morrison (2018) suggest that an embedded mixed-methods design allows for the integration of quantitative data into a predominantly qualitative study, thereby giving supplementary insights and a more comprehensive data. Using a mixed methods research approach intended to help offset the weaknesses of one approach and provide a wider picture of the challenges of climate change. It was important therefore to ensure that both quantitative and qualitative data are collected simultaneously and incorporated during presentation and discussion to effectively communicate the findings. The study was conducted in Dodoma Region. Mpwapwa District Council and Dodoma City Council were the study areas. Dodoma City and Mpwapwa Council were purposively selected to be involved in the study to capture the experiences of both urban and rural respectively. The study involved 20 geography teachers who were purposely selected considering their experiences in learning and teaching of space dynamics in all high schools. The sample for the study is indicated in Table 1.

Table 1
Summary of study location, sample and sample size

Region	District	Institution	Participants	Sample size		Total
				Males	Females	
Dodoma	Dodoma District	School 01	Geography teachers	2	1	3
		School 02	Geography teachers	2	0	2
		School 03	Geography teachers	2	0	2
	Mpwapwa district	School 01	Geography teachers	3	2	5
		School 02	Geography teachers	1	2	3
		School 03	Geography teachers	2	0	2
		School 04	Geography teachers	3	0	3
Total				15	5	20

Data collection was conducted through documentary review, interviews, and questionnaires. The study reviewed Geography textbook, syllabus, schemes of work, and lesson plans to assess the alignment of concepts,

objectives, competencies, as well as teaching and learning resources used. Semi-structured interviews were employed to facilitate discussion and clarification, thus allowing for an in-depth exploration of the challenges faced by teachers. This study involved a review of the syllabus to identify the intended competences, objectives, the proposed teaching and learning strategies and resources. Again, a review of geography text book intended to check its alignment with the syllabus while the review of schemes of work and lesson plans intended to check the alignment of competences, objectives and teaching and learning strategies and resources used. Open-ended questionnaires were employed to collect data on the general and specific space dynamic challenges to obtain a comprehensive data and triangulate the findings. An average mean score and some specific item means scores were used to interpret the findings.

To ensure the reliability of the questionnaire, Cronbach's Alpha was calculated to ensure correlation of questionnaire items. The correlation analysis test indicate that an overall alpha maximum value was α=0.914 and a minimum of 0.67 suggesting that the scale used range from highly reliable (strong) to moderate (reasonable) suggesting that they all measured related constructs (See Appendix 1). The study employed a thematic analysis method for qualitative data. The process, involved data transcription from verbatim to text, translating from Swahili to English, studying, segmenting. grouping, and re-reading to create themes and meaningful logical information from the qualitative data (Byrne, 2022). Responses from interviews were coded and analyzed using Microsoft Excel. The Quantitative data were analyzed using figures and tables indicating the percentile (qualitative data) or mean and standard deviation using SPSS version 27. The research ethics committee of the University of Dodoma issued ethical clearance and research permits. The informed consent was obtained from all the participants. In respect of confidentiality and academic honesty, the participants' identities were concealed and instead, code numbers were used. Besides, paraphrasing, and citation were used to avoid plagiarism.

FINDINGS

Perceived general challenges of teaching space dynamics

The analysis indicates that teachers perceived the complexity of the topic (28.79%) and the lack of sufficient teaching and learning resources (21.21%) as the key challenges to effectively teach space dynamics

competencies. According to some teachers, the complexity of the topic is associated with the presence of abstract concepts, such as pressure, which cannot be directly observed or physically manipulated. Additionally, some teachers claimed that students had negative attitude towards learning of space dynamics. They believed that space dynamic was difficult to learn thus making it difficult for them to actively participate in the learning process. Generally, teachers perceived that lack of teaching and learning resources especially weather measuring equipment was impeding teaching and learning of space dynamics. Reflecting on the general challenges on teaching the topic, some teachers stated:

> It is difficult to explain some concepts that are not seen by learners. For instance, the arrangement of air masses, pressure differences.... When you tell them that a given area has high pressure, they don't understand what it is because they cannot see it (TD01-01, 2024).

The other teacher also had these to say on the association between field and teaching of abstract constructs:

> We teach the topic without going to the field. We do not have weather measuring devices to teach the topic practically. The weather measuring devices are expensive and the school has no enough fund to buy the devices. We are forced to take students to a weather station to teach practically. Still the school administration will not give you money… Sometimes, I tried to convince students to contribute but at the end, only few contributed. (TD04-02, 2024).

Also, another teacher gave one's views on the negative perception of students regarding the difficultness of the topics:

> Some students have negative perception of learning the topics. Some concepts are abstract and terminologies used are difficult to students. Even some teachers believe that space dynamics is difficult to teach. The negative perception is communicated from teachers to learners and from learners to learners. Form six students have been telling form five students that space dynamic and surveying are difficult topics (TD01-05, 2024).

The quotations based on what teachers said indicate that the teaching and learning of space dynamics is constrained by complexity of the topic and insufficient teaching and learning resources. For example, nearly 29 percent of the interviewed teachers said that the foundational knowledge necessary for teaching the topic was a key challenge in teaching space dynamics. Teachers associated the difficultness of the topic with its being rooted in poor educational background to the topic during their high school education. The findings further reveal that more than 21 percent of

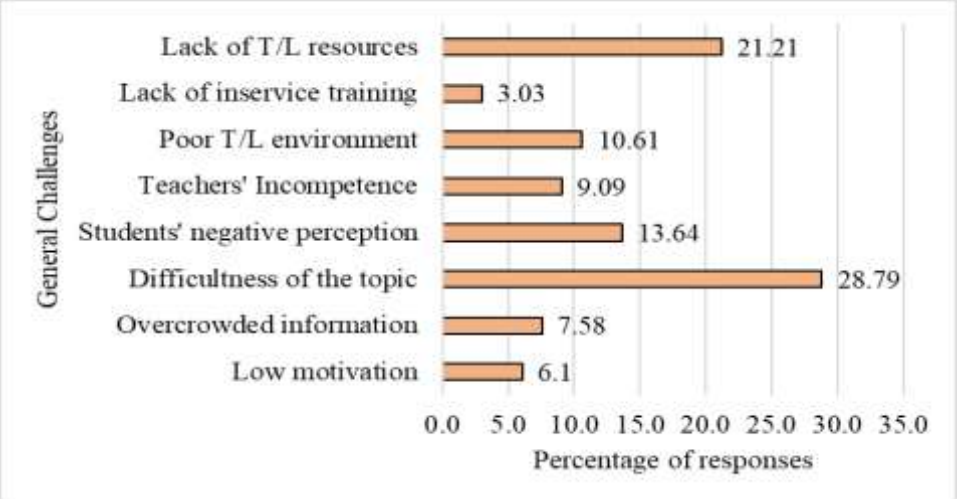
the teachers' responses admitted that insufficient teaching and learning resources was hindering students from accessing hands-on and collaborative learning opportunities that were crucial in the learning process as proposed by the constructivism learning theories. It should be noted that the presence of negative attitude towards learning space dynamic increases the complexity of teaching space dynamics in secondary schools. These limitations underscore the need for an in-service training program for geography teachers. Such professional development initiatives would serve to enhance both their subject-matter expertise and pedagogical capabilities, thus increased motivation to teach the topic. Again, it underlines the need for teachers to collaborate with other stakeholders to develop intervention to improve the pedagogical aspect.

Furthermore, while interview responses reflect a relatively low percentile rate (3.03%) regarding a lack of in-service training as a challenge hindering the teaching and learning of space dynamics, the questionnaire results present a noticeably higher mean score (4.80), hence strongly suggesting that inadequate in-service training is a significant obstacle. This discrepancy may reflect inconsistencies in teachers' responses, lack of confidence, or a lack of self-reflection regarding their teaching practices. Nevertheless, the interview findings indicate that some geography teachers were in eager need of training to improve their knowledge and skills in teaching space dynamics. The findings from teachers highlights the absence of in-service training for geography teachers, which is critical for the effective implementation of a competence-based curriculum. Additionally, there appears to be a perception that geography teachers are marginalized in the allocation of in-service training opportunities. This perceived inequity may contribute to a decline in teachers' motivation to teach the subject. Such disparities reflect unequal and insufficient provision of professional development for secondary school teachers. Emphasizing on this, one of the teachers was noted as saying:

> I have never participated in any seminar…. In our school, we just observe science teachers going to participate in seminars and workshops but we as geography teachers, we have never had that opportunity… But we are still waiting for the Government to remember us (TM02-02, 2024).

Figure 1. Presents the findings from the interviews on the general challenges of teaching space dynamics in secondary schools in Tanzania.

Figure 1
General Challenges of Teaching and Learning Space Dynamics



The findings indicate an average mean score of 4.05, suggesting that teachers generally agree to strongly agree with the identified challenges as presented in Table 2. These results underscore the complexity associated with teaching space dynamics in secondary schools in Tanzania. Specifically, questionnaire findings indicate that teachers agreed M=4.00 that they were constrained by lack of knowledge of some concepts (incompetence) and insufficient teaching and learning resources M=4.65 as they were teaching space dynamics. These challenges may undermine teachers' motivation and confidence both of which are critical for effective instruction. Additionally, the findings suggest that teachers perceived that the curriculum was overcrowded, which might hinder the successful implementation of the intended competencies. These questionnaire results support the interview findings that recognize incompetence and insufficient resources as among the challenges of teaching space dynamics. Table 2 presents the analysis of questionnaire items examining the challenges faced by teachers when planning and delivering teaching space dynamics within the context of ever-changing climatic conditions.

Table 2: General Challenges of Teaching Space Dynamics

Questionnaire items	Mean	SD
Lack of teaching and learning materials for teaching climate change	3.80	1.01
Lack of clear knowledge of some concepts in space dynamics	4.00	0.56
Overloaded space dynamic content	4.20	0.95
Mismatch between the syllabus and text book	3.90	1.07
Assessing beyond the syllabus in the final examination	3.10	1.41
Insufficient time to effect students' competence	3.85	1.04
Lack of past and current data on climate	3.85	1.09
Poor background of space dynamics topic	3.90	0.97
Lack of teachers' in-service training	4.80	0.41
Lack of some of the instruments used to measure weather elements	4.65	0.75

Key: 1=Strongly disagree 2=Disagree 3= Undecided 4= Agree 5= Strongly agree

Source: field data (2024)

Challenges Associated with Teaching and Learning Strategies

The results from the analysis show that 59.09 percent of the teachers' responses disclosed insufficient facilities as the major challenge associated with space dynamics teaching and learning strategies (figure 2). In the details of their description, they pointed out that insufficient facilities included lack of fund, lack of weather measuring instruments, and other teaching materials. It should be noted that space dynamics need students to engage in activities such as observing, measuring and recording weather parameters. As such, lack of weather measuring instruments, was found to impede teachers' and students' intention to engage in practical activities. This reflects the broader gap in providing practical and interactive learning activities in the school context due to lack of facilities, interest and time. Reflecting on this challenge, one of the teachers said:

> The challenge is on providing practical activities such as measuring and recording weather elements because of lack of the instruments used to measure weather elements. We can borrow from the science laboratory some equipment such as the thermometer and barometer, but other instruments are not found. It is better for the government to buy these instruments to enable us to teach practically (TM01-04, 2024).

On the other hand, another teacher commented on the challenge associated with the content coverage of the topic:

> The content is very wide so, some activities are difficult to provide. For instance, interactive teaching and learning activities take time compared to lectures. A-level students prefer the use of lecture method to participatory methods because it helps to cover the content quickly. Students like to cover the content so as to pass the examination (TM04-03, 2024).

Furthermore, regarding the use of participatory methods, another teacher added that:

> Participatory methods such as discussion are effective in teaching and learning space dynamics. But, if you give them an assignment to discuss and present, they claim that it is difficult to find the materials. This is because some of the information is not included in the text book. We encourage students to buy some pamphlets so as to be able to use participatory methods (TD01-02, 2024).

The findings further emphasize the challenges teachers were facing in implementing practical and interactive teaching methods. Some teachers were avoiding interactive teaching methods because of the overcrowded curriculum that was making it difficult to cover all topics using collaborative learning activities. This reflects a tension experienced in trying to cover the content to enable learners pass examination over practical implementation of knowledge and skills gained. This suggests that teachers were opting to use lectures to complete the syllabus rather than using interactive methods that were more effective for learners to develop a deeper understanding. The reason for not choosing interactive method was that, the method itself required more time to accomplish the teaching. In contexts where student performance is prioritized, teachers may be inclined to adopt instructional strategies that allow them to cover the curriculum quickly, potentially at the expense of competency-based learning.

In addition, the analysis of teachers' explanations revealed that schools lacked sufficient funding to support teachers in implementing various teaching and learning activities. For instance, many teachers expressed a desire to organize study tours to weather stations to provide students with hands-on opportunities to observe and record weather parameters. However, financial constraints prevented them from going to weather station where it could have facilitated such an actual experiential learning activity. Reflecting on a challenge in organizing study tours, one of the teachers, stated that:

> It is difficult to organize a study tour to a weather station because of the distance. The school does not have enough funds to meet expenses of

> such tours. I tried to convince students to contribute money but only few of them managed to do so. However, it is difficult to go with five students. The syllabus suggests students to do some activities such as observing and recording weather elements. However, these activities require students to use weather measuring equipment that are not available in our school. (TM01-05, 2024).

Similarly, another teacher added that:

> There is a challenge in organizing a study tour because students do not have money and the school does not have any fund. Therefore, is a need to have a study tour to a weather station but organizing such a tour is difficult. Apart from lack of funds, there are lots of procedures to follow in getting permission to take students to a study tour. (TD01-02, 2024).

These findings indicate that schools were not supporting teachers in organizing the study tours to weather stations which would provide students with an opportunity for experiential learning. It was noted that teachers recognized the value of study tours in enhancing students' understanding of weather parameters as they would provide real-life experience. However, the use of this method has been hindered by financial constraints. As the findings revealed, some teachers were attempting to overcome the challenge by asking students to contribute money to make it possible to travel to the weather stations but many students could not afford. These findings suggest that the problem was not teachers but it was schools' lack of funding ability to support teachers in the process of attaining the intended curriculum goals and students' desires. This finding underscores the importance of the government to increase institutional funding either by own sources or by collaborating with other agencies to support funding for practical learning experiences.

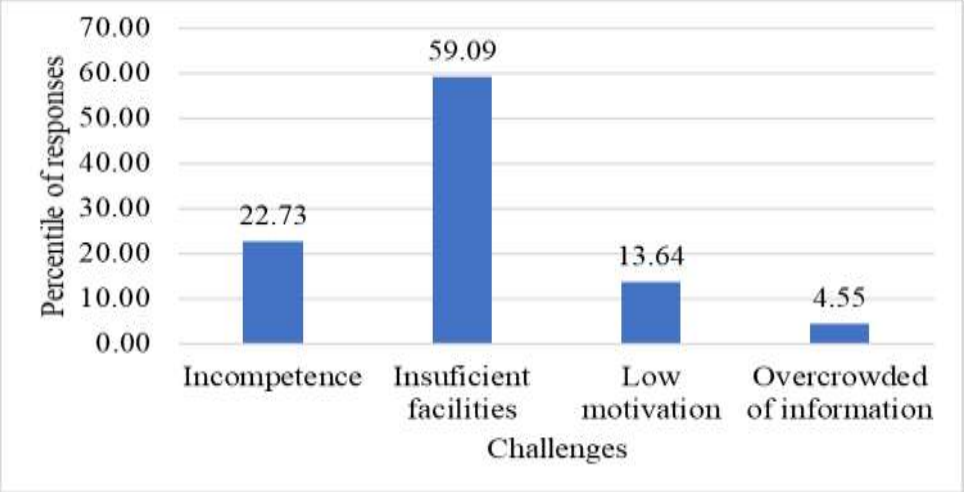
Besides, the findings based on syllabus analysis indicate that the use of teaching and learning strategies such as; watching video clips dynamics, organizing study tour and measuring weather parameters, designing weather measuring instruments using locally available materials were proposed. The findings based on the analysis of documentary review and interview indicate that very few teachers were using these activities. Again, the analysis of schemes of work and lesson plans indicate that teachers did not plan to implement practical activities in their lesson plans. This finding was also noted through the interview where teachers admitted that they were unable to provide practical activities due to lack

of resources. Emphasizing on this, one of the teachers was noted as saying:

> Lack of equipment is a challenge. In teaching, the teacher needs to use teaching aid so that the topic is understood. However, the challenge is lack of equipment. For example, you need measuring devices so as to teach well weather observation and recording. The problem is that many schools do not have the devices. So, the teachers teach more theoretically or superficially (TM02-03, 2024).

Furthermore, the results indicate that low motivation of both teachers and learners is among the challenges of implementing some of the space dynamics' teaching and learning activities. Low motivation was attributed to incompetence on the part of the teachers and negative attitude on the part of learners. It should be borne in mind that students' motivation plays a crucial role for the effectiveness and efficiency of teaching and learning activities in schools On this regard, Natiqi, (2024). proposed that students' motivation plays a crucial role for the effectiveness and efficiency of teaching and learning activities in schools. This reflects ineffective implementation of teaching and learning activities in one hand and on the other, a gap between the intended knowledge, skills and competence in the syllabus and classroom implementation. Figure 2 presents detailed explanations of the interview findings on the challenges facing teachers in executing teaching and learning strategies as they were teaching space dynamics.

Figure 2
Challenges associated with teaching and learning strategies



Challenges associated with teaching and learning resources

Figure 3. presents the challenges faced by teachers regarding space dynamics teaching and learning resources. The results from the analysis show that 53.13 percent of the responses from interviews indicate that lack of weather measuring equipment was a major challenge associated with space dynamics teaching and learning of resources. Other teaching materials that were insufficient included the globe, and world the map. In response to this, teachers had these to say:

> Lack of equipment is a challenge. In teaching, the teacher needs to use teaching aids so that the topic is understood. Now the challenge is the availability of equipment. For example, you need measuring devices so as to teach well. The problem is that many schools do not have the devices, so the teachers teach more theoretical than practical (TM01-02, 2024).

Additionally, another teacher added that:

> The challenge is that teachers do not improvise the devices using the locally available materials. It is difficult to improvise devices such as anemometer, Hygrometer, and barometer. We need to use real devices so that students can read and record weather elements. We expect the school to buy or the government to bring those devices, but they are so expensive. (TM04-02, 2024).

This implies that teachers are not provided with the important resources to effectively teach space dynamics. Additionally, the findings indicate that teachers were not making efforts to find an alternative way to get the required resources. Thus, there is a need to capacitate and facilitate teachers for effective teaching and learning activities that will enable learners to actively participate in the activities that reduce the adverse impact of climate change on the environment. Besides, the teachers were not appreciating the role of improvisation in filling the gap created by insufficient teaching and learning resources. If teachers are not motivated to improvise materials and the school do have the funding ability to buy enough and relevant resources, then students will continue learning without supportive resources. In this context, students may struggle to grasp space dynamics concepts. This gap can lead to a lack of active students' engagement and eventually hinder their overall learning.

Again, the teachers pinpointed that lack of quality reference materials was another challenge associated with space dynamics teaching and learning resources. References such as textbooks and supplementary books were reported to be insufficient. In addition, the references were found to use

difficult language, while missing some concepts. Furthermore, the findings from interviews indicate that schools lacked enough reference materials. This was found to make it difficult for teachers to facilitate learning through giving assignments in order to cover the content as proposed in the syllabus. This was one of the challenges that were restricting students' independent study and classroom learning as well. Reflecting on the challenge of reference materials, one of the teachers had these to say:

> One of the challenges of teaching space dynamics is lack of enough teaching and learning materials. Sometimes you want to give them a task or assignment but they cannot accomplish it because they don't have reference materials. Sometimes there is lack of some concepts in the text book and supplementary materials (TD01-01, 2024).

Additionally, another teacher added:

> Sometimes the text books and supplementary materials lack some concepts and information. Books do not include weather and climatic data. It is difficult to find data on the climate change since 1850s as indicated in the syllabus. We lack books that are straight forward and sometimes the language used in the books is difficult to students (TM02-02, 2024).

The study findings indicate that most schools in Tanzania do not have adequate teaching and learning resources like digital materials and weather measuring instruments. As far as teachers were concerned, they claimed that the absence of activities for teaching either concretely or collaboratively made virtually all hands-on resourceful teaching impossible. Moreover, inadequate technological equipment emerged from the analyzed responses. During the interviews about teaching and learning resources, respondents reported the absence of the internet, video clips, and projectors as critical resources. It therefore follows that the relative effectiveness of teaching and learning of space dynamics is undermined by the absence of adequate teaching and learning resources, as illustrated in figure 3. Moreover, the analysis of the files of lesson plans devoid of the documents showed that there was inadequate provision of resources to be used for teaching and learning.

In addition, the teachers believed that lack of technological devices and services was another challenge in teaching space dynamics. Digital devices such as projectors, computers, and internet service, were a challenge facing the implementation of space dynamics competences.

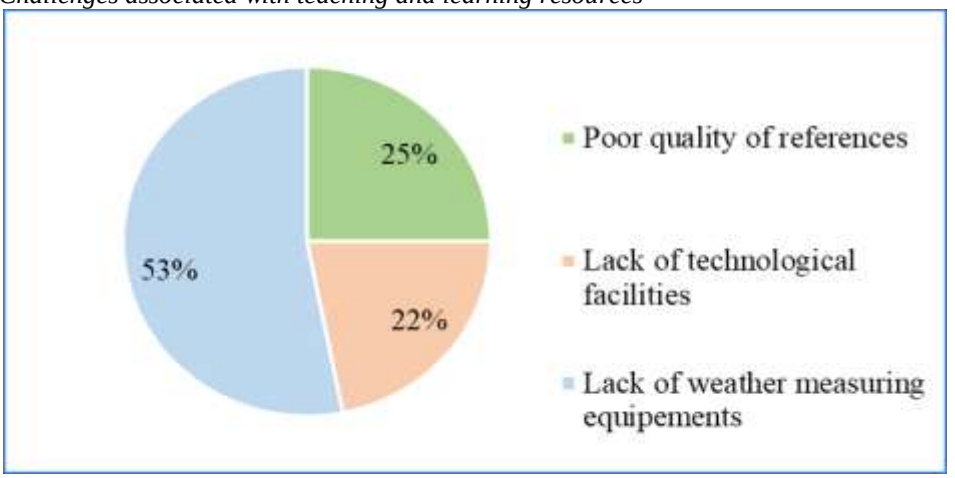
Due to lack of enough and quality reference materials, the remaining option was the use of internet source. If digital tools and internet services were unavailable, then the problem would become worse. In connection to this, one of the teachers had these to say:

> We lack assistive technology for teaching as well as videos that can be used as learning aids. We don't have computer, projector and even internet service. You have to buy you own bundle or else you cannot access the internet sources… Bad enough, most of the relevant online books are sold in dollars. (TM02-02, 2024).

On the same matter, another teacher added:

> We lack of projector which otherwise we would use it as an ICT in teaching of space dynamics. Materials worthy of printing found in the internet can help but the academic master cannot allow you to print the materials every day. There is a problem of depth of information in some concepts or sub topics, therefore, it is important to find some information from the internet (TM04-01, 2024).

Figure 3
Challenges associated with teaching and learning resources



Again, the findings presented in Table 3 show the results of the alignment between the syllabus and textbook. It indicates a minor mismatch between the syllabus and the textbook. For instance, the formulae of how to calculate humidity coefficient, weather data and illustrations on how to plot graphs and/or map, and description of variation of climate since 1850, were not covered in the textbook as indicated in the syllabus. This indicates that teachers had to make efforts to find materials from other

sources such as supplementary books, online books, and other sources. See Table 3:

Table 3
Analysis of the objectives in the A-level Syllabus and content in the text book

Objectives covered in the text book	Objectives uncovered in the text book
By the end of the topic the student should be able to: Distinguish between weather and climate Analyze the major elements of weather Account for instability in the atmosphere Analyze vertical structure of atmosphere Measure weather elements Read record and analyze weather data Differentiate heat from temperature Explain weather forecasting & its importance Define climate change Explain the majour causes of climate change. Describe the impact of climate change Describe the major types of climates Explain climatology and describe the typical characteristics of climatic regions of the world	Calculate humidity coefficient Use weather data to plot graphs and map Describe fluctuation of climatic conditions since 1850 Debate on sustaining and reducing its impact climate change

Table 4 presents teachers' responses from questionnaire on the challenges associated with space dynamics teaching and learning resources. The results recorded an average mean of 2.79 that indicate that generally, teachers were less satisfied with the availability of teaching and learning resources in their schools\. The results indicate that teachers' responses were between neither satisfied nor very dissatisfied. This indicates that teachers needed some improvement in teaching and learning resources available in schools. Specifically, teachers were very dissatisfied with the availability of weather-measuring equipment. Based on the findings generated from questionnaires and interview, this was reported to be the major challenge of teaching and learning resources. as.

Table 4
Teachers' Satisfaction with the Availability of Teaching and Learning Resources

S/N	Questionnaire items	*Mean*	*SD*
1	Availability of equipment used to measure weather elements	1.65	0.75
2	Availability of good textbooks	3.75	0.85
3	Availability of enough supplementary books	3.00	1.03
4	Availability of electronic/digital sources	2.50	1.24
5	Availability of other teaching and learning materials	3.05	1.05

Challenges associated with realization of the intended space dynamics competence

The findings based on the syllabus analysis indicate that generally, the syllabus intends learners to develop competence as they learn space dynamics in schools. The analysis indicates that the syllabus expects students to engage actively in activities which reduce the impact of the adverse effects of weather and climate on environment. This is geared to develop ability among learners to adjust to ever-changing climatic condition for sustainable development. The syllabus adheres to the international agenda indicated in the sustainable development goals (SDGs) Goal number thirteen (13) 2025-2030 which *inter alia,* intends to improve education, create awareness-raising, and peoples' capacity to adapt and reduce the impact of climate change (United Nations, 2016).

Notwithstanding, some teachers were unable to distinguish between competence and objectives. For example, teacher TD03-01 (2024) had written "Students should be able to describe natural and human impacts on weather and climate" as a competence. This indicates that the teacher was unable to distinguish between competence and objective or break down the competence into attainable competences in each specific lesson. A syllabus is just a flexible guide for teachers that prescribes the topic and concepts expected to be implemented in the classroom (Parkes, Harris, Parkes, & Harris, 2010).

On the other hand, the analysis shows that some of teachers' scheme of work and lesson plan were missing space dynamics competences as indicated in Table 5. The analysis of schemes of work and lesson plans indicates that teachers (44%) did not consider competence in their scheme of work and lesson plans. For the case of lesson plans, 'not observed' indicates that the teachers did not consider competence in any of their lesson plans. However, it should be noted that some teachers indicated competence but in relatively few lessons. This indicates that competence was not being prioritized when teachers were preparing their lessons. This finding underscores a gap between implementing the intended curriculum and the actual implementation of the same. This indicates that teachers were choosing and planning to implement the objectives that they could teach comfortably while leaving aside those which they were not comfortable to teach.

Table 5
Teachers' consideration of space dynamics competences in their preparations

Teachers' code	Scheme of work	Lesson Plan
TD01-01	Not observed	Observed
TD01-02	Not observed	Observed
TD01-03	Observed	Not observed
TD02-01	Observed	Observed
TD03-01	Observed	Observed
TM01-01	Not observed	Not observed
TM02-01	Observed	Observed
TM03-01	Not observed	Not observed
TM04-01	Observed	Observed

The results based on interview also noted that teachers were unable or uninterested on the development of competences. For example, the quotation from teacher TD01-02, 2024, indicates that teachers were focusing much on developing learners' ability to answer the examination questions at the expense of developing the intended learning competence in space dynamics. The teacher claimed that questions focusing on competence seemed to be difficult to learners. Besides, the teacher ascertained that learner were not interested in developing the competence because they could opt not to answer space dynamic question. This clearly indicates that learners were not interested in competence development rather examination performance. Emphasizing on this challenge, one of the teachers said:

> When you ask students questions that focus on competence, it becomes very difficult for them…Students concentrate more on their ability to answer examination. Because space dynamics question is optional in national examination, students can opt to answer questions from other topics that are not competence-based (TD01-02, 2024).

On the same line of argument another teacher added:

> Due to time and interest of our students, we are forced to concentrate on helping learners to answer national examinations… We focus much on questions that will appear in the national examinations. Another challenge is that, when you ask students questions that focus on competence, it becomes very difficult for them to attempt them (TD01-02, 2024).

Again, the findings presented in Table 6 show the questionnaire's results on teachers' ability and commitment to effect space dynamics competences. Results show that with a M=2.77 generally, teachers recorded a satisfactory to good ability in aligning the assessments,

resources and activities with the competence. The constructivism alignment theory emphasizes that teachers have to align assessments, resources and activities with the intended learning outcomes to ensure effective learning. Therefore, if the teachers could not align assessments, resources and activities to the intended learning competence, the attainment of the competence would be difficult. This clearly reflects the broader gap between the intended curriculum and the implemented one, thus calling for a closer monitoring and evaluation of teaching and learning in schools.

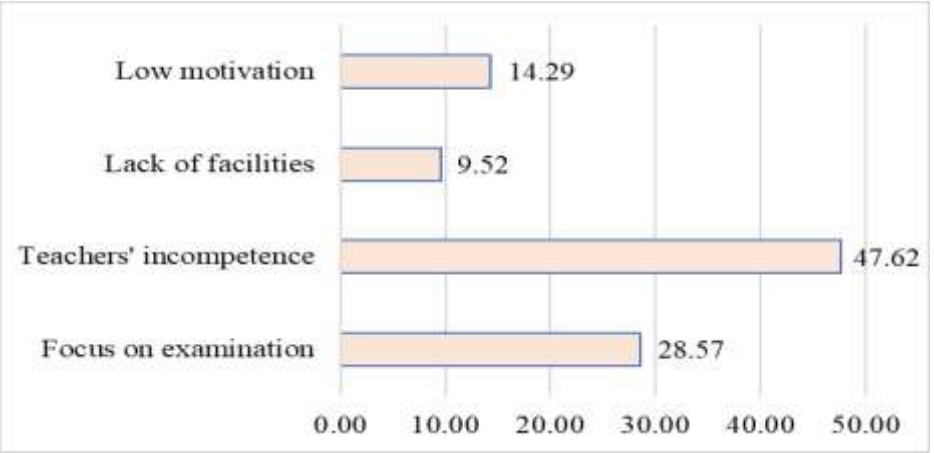
Table 6
Teachers' Ability to Effect Space Dynamics Competences

S/N	Questionnaire items	*Mean*	*SD*
1	Access to past and current data on climate change	2.64	1.28
2	Preparation of space dynamic-teaching and learning resources	3.43	1.02
3	Align teaching and learning resources with the competence	3.14	1.35
4	Align teaching and learning activities, with the competence	2.93	1.14
5	Align teaching and learning assessment with the competence	2.50	1.51
6	Mobilize learners/resources to mitigate climate change	2.64	1.08
7	Recommend teaching and learning resources for learners	2.86	1.23
8	Suggest a specific web site for learners to access	2.00	1.30

The findings show that 47.62 percent of teachers' responses indicated that teachers' incompetence was a great challenge in assessing space dynamics competences. Some of the teachers unveiled that they were unable to construct competence-based questions. However, it should be reiterated that assessing the intended learning outcomes forms an important part of teaching and learning. Assessment is an eye opener to teachers regarding the effectiveness of teaching and learning activities. The challenges in assessing competencies reflect broader gaps in teacher training and curriculum design, thus underlining the need for targeted professional development to sharpen their knowledge and skills. Figure 4. presents the findings on challenges faced by teachers in assessing the intended competences. Regarding this, one of the teachers had these to say:

> Of course, now if I have a challenge to understand some concepts, how can I know whether the students have acquired the competence or not. We need to have workshops to learn some difficult concepts and how to assess students' competence. Most teachers cannot construct competence-based questions. (TM03-01, 2024).

Figure 4
Challenges in developing, and assessing space dynamics competences



DISCUSSION OF THE FINDINGS

First, the findings indicate that complexity and insufficient knowledge and skills constrain space dynamic teaching and learning in Tanzania. These findings relate to the previous studies such as studies by Apollo, and Mbah (2021), Liu et al, (2015), and Henderson, et al, (2017) which emphasized on the complexity of climate change education due to its dynamic nature and the existing knowledge gap among both teachers and students regarding key concepts. This observation also correlates with the work of Mochizuki, and Bryan, (2015); Apollo, and Mbah, (2021) who noted that, the complex nature of climate change poses difficultness in understanding its causes, effects, and the role played by individuals in influencing or mitigating its impact. Similarly, Henderson et al. (2017) identified a knowledge gap among teachers, which may be linked to the fact that climate change was not adequately covered during their formal schooling.

Second the findings indicated that teachers and curriculum developers recognized that collaborative activities such as group discussion, and presentation has the power to effect space dynamics competences in Tanzania. This finding is in line with the findings from different studies such as Belova, Eilks, and Feierabend, (2015); Kisanga and Gabrieli, (2018); Nevenglosky, Cale, and Panesar Aguilar, (2018); who testified that collaborative activities are effective in promoting learning. Similarly, Pham (2011) supports the findings with the view that when students

collaborate with peers and teachers through reflections, they will develop multiple skills and experiences that can be applied to real life in a natural setting. Collaboration is also recommended in the geography syllabus as it gives room for imitation of different practical skills and development of learners' ability to construct knowledge as proposed in constructivism alignment learning theory (Ministry of Education, Science and Technology, 2023a). However, the results revealed that teachers opted to use lecture so that they could cover the content on time for learners to be able to answer examination questions. Thus, teaching and learning in Tanzania should not only be geared towards memorization of facts in order to pass examinations, rather; it should be geared to enable learners apply the knowledge for the benefit of the community (Msuya et al., 2014).

Third the findings indicate that scarcity of resources in teaching and learning of space dynamics in secondary schools in Tanzania is a key challenge that needs to be fixed. The current findings are in line with the report by Mupa and Chinooneka (2015), Nevenglosky et al (2018), and Tambwe, (2019) that insufficient quality teaching and learning resources is a factor leading to ineffective teaching and learning in schools. In specific, Apollo and Mbah (2021) noted that climate change education is hindered by lack of adequate resources. Again, the Tanzania Education and Training Policy 2014 as revised in 2023, acknowledges that there has been a shortage of quality teaching and learning resources that weaken teaching and learning in Tanzanian schools.(United Republic of Tanzania, 2023). The study by De Guzman, Olaguer, and Novera (2017) disclosed that the use of instructional resources is important in improving learning. The challenge of inadequate resources was noted from both interviews and questionnaire responses. It can be argued that the Government, and teachers in collaboration with other educational stakeholders must find solution to scarcity and insufficient resources if space dynamic competences are to be developed.

Insufficient resources can hinder effective implementation of the curricula. The Tanzania Education and Training Policy 2014 as revised in 2023 acknowledges that effective implementation of curricula in various levels depends on the availability of relevant teaching and learning resources although there has been a shortage of quality teaching and learning resources in various levels (URT 2023). Similarly, Nevenglosky et al (2018) pointed out that, for teachers to be efficient in implementing

curriculum, they need a variety of teaching and learning resources. According to Zhong (2019), the use of different teaching and learning resources can raise learners' interest in learning the content and eventually promote effective learning. It thus poses challenges to teachers' selection of learning resources that would appeal to different learning needs of different learners. Therefore, the availability of different teaching and learning resources can appeal to different learning styles and learning needs of different learners in the classroom.

The results indicate that inadequate teaching and learning facilities is an obstacle to the implementation of space dynamics competences (competence-based curriculum) (Tambwe, 2019). It has been argued that insufficient teaching and learning resources particularly weather measuring equipment is a stumbling block to the provision of practical activities that give an opportunity for experiential learning. Practical activities have the potential to help learners reflect on real life environment and develop ability to implement the knowledge and skills gained in the course of study (Millar, 2004). These findings correspond to that of Kisanga and Prosper (2018) which reported lack of practical activities during learning of elementary survey in Tanzania. The use of practical activities promotes experiential learning which is vital in the implementation of the philosophy of education for self-reliance (ESR) as it involves learners into concrete activities that can merge theory and practice (Ahmad, Krogh, & Gjøtterud, 2014). The need for resources not only facilitates practical engagement with the material but also enhances students' conceptual understanding through experiential learning (Tambwe, 2019). Similarly, Mertayasa, Sumarni, and Indraningsih, (2024) reported that when students engage in experiential learning, they develop motivation to learn, develop critical thinking skills while blending real-world experiences.

Fourth, teachers pointed out that inability to construct competence-based questions and poor mastery of space dynamics knowledge and skills were among the setbacks of assessing the competences during teaching and learning. Incompetence in assessing space dynamics competences reflects inadequate training on competence-based curriculum that has prevailed for decades since Tanzania shifted from content-based to competence-based paradigm in 2005. The findings support what was reported by Tambwe, (2019) that among the challenges facing teachers in implementing competence-based curriculum was incompetence. Limited

pedagogical knowledge on how to develop competences among learners is a serious constraint that can hinder learners' ability to counter balance the adverse impact posed by climate change in their lives. This finding implies the need to prepare professional development programmes and digital networking to enhance collaboration among teachers and other educational stakeholders.

Lastly, the findings indicate that focus on examination and teachers' incompetence are among the factors hindering implementation of competence-based curriculum. Some of the teachers claimed that students were interested in the preparation to pass the final examination. This concurs with the report by Lupeja and Komba (2021), who revealed that teachers and learners focused on memorization of facts to pass examination that would qualify them for further studies. Gabrieli and Elisa (2017) asserted that that teachers' inability to effect competence based curriculum has remained a challenge for decades. The findings of this study support the previous findings something that indicates that the focus on examination is still an obstacle to the implementation of competence-based curriculum. This implies that competence-based assessment is not prioritized in continuous assessments in Tanzania. These findings underscore the gap between intended and implemented curriculum. Since competence-based uncovers learners' ability to construct and apply knowledge and skills gained as proposed in constructivism alignment learning theory, efforts need to be made to ensure effective implementation of competence-based curriculum. Nevenglosky, Cale, and Panesar Aguilar, (2018) recommended that alignment between the intended and the implemented curriculum is crucial to the development skills required for learners to succeed in the higher levels of learning.

CONCLUSION AND RECOMMENDATIONS

The study concludes that if measures are not taken, the intended curriculum competence of developing ability to participate in the activities that reduce the adverse impact of climate change cannot be realized. Teaching and learning are geared to enable learners pass examinations at the expense of competences. If learners are unable to develop the intended competence, they will not be able to adjust themselves to weather and climatic changes occurring in their environment. Eventually this will impede their endeavor to ensure sustainable development. The study recommends that the Government,

and schools need to allocate enough budget to buy relevant teaching and learning materials and conduct professional development for teachers to improve their knowledge and skills in space dynamics and other complex topics. The educational administrators should consider professional development for Geography teachers that seem to be inadequate in secondary schools. This will boost their confidence and motivation to teach the topic more effectively. Again, schools should procure digital tools and internet to ensure interconnectedness and collaboration among teachers and other educational stakeholders. This will help teachers to share and gain experience in teaching the topic and other topics as well. Furthermore, teachers need to learn how to design and improvise teaching and learning resources to ensure effective teaching and learning of space dynamics in secondary schools.

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