

# The Role of STEM Education in Teaching and Learning in South Africa's Underprivileged Societies

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## Abstract

STEM (Science, Technology, Engineering, and Mathematics) education in some quarters of African society is wrongly perceived because the importance of this contemporary educational approach to knowledge is not properly taught, understood, and harnessed among teachers and learners. The fact that STEM education is a recent educational development and a subject of interest, especially within African educational institutions, suggests that its benefits in teaching and learning are not well-maximized and enjoyed by teachers and students. Using particular pieces of literature and the outcomes of a case study of several discussions with some students and teachers in Cosmo City, this researcher highlights that some underprivileged people's perceptions regarding the current status and the importance of STEM education were misunderstood. The researcher used the concept of "travel" as a topic to explore how STEM education can be taught and understood among students. Other objectives of this research are to encourage government educational agencies and other organizations concerned with educational development to know and assist underprivileged schools in effectively providing STEM education. The study was achieved by expounding on some of the problems underprivileged schools in South Africa face concerning STEM education. The result obtained from this research indicates that the poor or inadequate utilization of STEM education is responsible for its wrong perception in underprivileged communities in most African societies. The researcher concludes that adequate STEM education that includes the provision of necessary study materials and trained teachers will result in the best maximization of this form of knowledge among all sundry, irrespective of an individual's socio-economic background.

**Keywords:** Cosmo City, computer, education, female, science, teaching and learning

## Introduction

The problem of unemployment among many South African graduates is paramount. It is vital at this juncture to note that South Africa is one of the fastest developing nations in Africa, has a population of about 60.14 million people, and Gross domestic product (GDP) growth of 904.743 billion as reported by Statistics SA (cf. Stats SA 2021, pp. 6-7). Out of this estimate, 29% of the South African population is unemployed, 90% have no access to the internet for educational purposes, and only 21.5% own computers at their respective homes for educational purposes (Jantjies 2019; Joubert 2022). While some students find it challenging to adapt to science-based literacy subjects for the above reasons, the teachers also struggle to understand and teach those science-based subjects, especially mathematics, engineering, and other computer-based subjects. Trevor Pols concurred with this view: "... teachers are not as comfortable teaching technology and engineering in primary and high schools" (Pols 2019). Given this, there is a need to look into this modern integration of science-based knowledge called STEM, which gives both learners and teachers a better opportunity to teach and apply science-based knowledge to real-life experiences.

STEM education is an interdisciplinary knowledge that combines different forms of subjects: Science, Technology, Engineering, and Mathematics, into a single subject with the sole

aim of creating a student-centered educational environment where teachers are required to guide learners to integrate and apply STEM subjects into real-life problems and experiences. The idea is to develop practical problem-solving skills using STEM (Sen et al., 2019). Within the South African context, the teaching and the learning of STEM subjects have remained a challenge that affects the skills development and the employability ratio of many graduates, especially those who were raised within the context of underprivileged schools and societies. The National Science and Technology Forum (NSTF) noted with dismay the poor level of performance in STEM subjects among South Africans, rating its passing rate to only 20%, suggesting an urgent need to revamp STEM skills among South African learners and teachers (Pols, 2019).

After the apartheid government was toppled and South Africa conducted an election where Nelson Mandela became the first democratically elected president, some changes took place in the arrangement of the society in South Africa. During apartheid, unskilled workers were employed by mostly white people in South Africa and squatter camps were created for them in the outskirts of many cities where there was no or where there was little supply of basic amenities (Hyslop 1999, p. 158). From 1994, people began to live in any part of South Africa and Cosmo City was formed by many people from squatter camps, thus making many residents underprivileged. Further government intervention led to the construction of modern houses and the provision of social

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DOI: <https://dx.doi.org/10.22159/ijoe.2024v12i2.50350>. Journal homepage: <https://journals.innovareacademics.in/index.php/ijoe>.

**Acknowledgments:** The author would like to thank the leaders and members of Africa Speaks International (ASPI) in South Africa and Nigeria for helping me with relevant guidance and information towards completing this research. The community members of Cosmo City and those residing in Ivory Coast Street are also commended for their assistance and connections in making me meet the academic authorities in Cosmo City. **Author's Contributions:** The author confirms sole responsibility for the following: Study conception design, data collection, results, and manuscript preparation. **Conflict of Interest:** The author has declared that no competing interests exist. **Funding Source:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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amenities for the people of Cosmo City. There is also a high population of African migrants in Cosmo City, which has led to high competition for resources, including the provision of education, leading to its scarcity (Hoffman et al., 2016). Public schools in Cosmo City are finding it difficult to accommodate all students and lagging in the number of science-based teachers they have. There seemed to be a general perception among some residents of Cosmo City that sciences are difficult subjects that must only be studied by the most serious people and also the ordinary people in society. This research addressed some of these perceptions.

### Review of the Related Literature

Teaching and learning are two significant instruments of the educational workforce globally. It is important to note that as society changes, so should there be a change in approaches to teaching and learning. In learning, change is fundamental because the learners' thinking and approaches to life are required to be influenced by the precipitates or results of learning.

Sequeira (2012) echoed that the aim of learning should be aligned with the transformational change that should occur in the learner's life and that this marks the primary purpose of learning. This is similar to the purpose of STEM education, which is aimed at causing a change to issues of life from the perspectives of the teachers and learners and with emphasis on the learners in which they are allowed to express themselves freely.

It is therefore not surprising that Sen et al. (2016) explained in detail the need to enhance STEM education in the twenty-first century especially due to the changing parameters of work and work places "the aim of STEM education is to train qualified individuals to meet the 21st century workforce needs" (p. 81). In other words, they thought that schools should be places that prepare learners for the workplace with an emphasis on the twenty-first century changing educational insights, which requires a change in approaches to work and curriculum usage: "... curriculum, content, and evaluations should be adapted to student skills and needs and focused on 21<sup>st</sup>-century skills" (p. 82).

On the importance of STEM education, Umoh (2016) noted that Africa can benefit so much from the knowledge of STEM, considering its rising population and developing structures that make it possible to educate learners on how to develop their territories by taking advantage of STEM education. He further said that STEM education can equip the teaming African students to face life challenges and make informed decisions, including creating life survival strategies to be relevant locally and globally. However, he noted with dismay that many African states are lagging in the training and sustenance of STEM teachers.

It is on this note that Kailer (2018) echoed a similar sentiment as Sequeira (2012) and explained that the twenty-first century poses a serious challenge to both teachers and learners to the point that both primary and secondary schools have now become a haven or a reservoir meant for training schools for post-secondary career opportunities and citizenship. Kailer stated that the primary purpose of STEM education is to equip learners with the relevant skills for innovation, creativity, critical thinking, and a problem-solving mindset.

FutureLearn (2021) noted STEM education has been explained as a process that requires an application of engineering design processes to solve a problem that pertains to day-to-day human activity. The engineering design includes approaches that include asking a question about an issue, conducting research, planning, creating, testing, and attempting to find improvements over an existing or newly found idea or theory. In other words, STEM teaching emphasizes project-based learning, problem-based learning, and inquiry-based learning that will lead to creating, thinking, and developing hypothesis and theories that explains certain activities or natural design nature. Unsurprisingly, the importance of STEM education has been listed to include critical thinking, independent learning, enhanced communication skills, digital literacy, creativity, self-reflection, and the creation of a problem-solving mindset.

Dare et al. (2021) also emphasized the importance of STEM education as helping to prepare students for a wider career opportunity using the students' prior knowledge and giving them

opportunities to think, create, and act on a problem. However, they decried the absence of a professional method or map to guide teachers in teaching STEM so that learners can better apply and appreciate the knowledge. In other words, these authors explained that teacher's professional development in developing and refining their independent approach to teaching STEM is lagging.

Amado and Carreira (2022) regarded STEM education as evolving due to the constant development and improvements that arise from this knowledge. As a result, they emphasized the need for continuous teacher training and retraining on applying STEM to boost learners' interest in the subject. In other words, they thought that the teachers of STEM subjects have little or no confidence in teaching the subject because they lack the expertise to demonstrate to learners how STEM knowledge can be applied in the classroom, thus, there is a need for teachers' professional development. However, they admitted that STEM education could be the most friendly and comprehensible means of teaching. Similarly, this research emphasizes the importance of STEM education despite the difficulty of applying the knowledge.

### Objectives

This researcher did a case study regarding secondary schools in Cosmo City to determine the role of STEM education in underprivileged societies. The researcher believes that many other underprivileged societies in South Africa share similar or closely related educational challenges where STEM education is needed but lagging due to the absence of teachers, the poor interest of learners, and their negative perceptions of the subject. The purpose of this research is to demonstrate how the teaching and learning of STEM education can be enhanced or taught using simple day-to-day illustrations that can easily be comprehended even among the underprivileged societies in South Africa. Other objectives include:

1. A show of the role and the perception STEM education in poor communities to provide suggestions on the way forward;
2. To encourage and motivate the government to increase its efforts in developing a curriculum that will address the challenges faced in teaching STEM education. This is achieved by expounding on some of the problems underprivileged schools in South Africa are faced with that pertain to STEM education;
3. To elaborate on the relevance of STEM in dealing with real-life realities, citing relevant references;
4. To motivate both educators and learners to be user-friendly in the admiration of the knowledge of STEM.

### Methodology

#### Design

The research studies the use and perception of STEM education, especially the residents of Cosmo City. The study uses teachers' questions to motivate the learners to suggest and create ideas about travels in connection with STEM education. The outcome of the research is a specific view within the context of Cosmo City and the perception of STEM education in S'Diphola Secondary School and this formed the bounded system and specification for this research.

#### Sample

Ten high school students, one female and nine males, were interviewed. The study is primarily a case study of grade 10 science students from S'Diphola Secondary School in Cosmo City. Their ages ranged from 14 to 17. Two teachers were also interviewed, and the teachers were all males, both of whom were qualified to teach learners in grades 9 to 12.

#### Tool

A questionnaire was administered among students and teachers and is divided into sections A, B, C, D, E, and F, as noted

in the questionnaire (see Appendix A). The questions were open-ended because a discussion was allowed by the learners in a group, and another response was required individually, where the learners had to write and speak about their opinions. Their views were questioned by themselves and others in the group, while opportunities were given to the learners to be creative as well. The two teachers interviewed were asked about the suitability of their teaching classes in terms of STEM education and the availability of ICT-related items. All of them, or 100%, believe that Cosmo City Secondary School is lagging regarding the availability of ICT gadgets for teaching STEM.

### Data Collection

The researcher used the constructivist interpretivist learning theory to facilitate a class with the learners where the topic "travel" was discussed and demonstrated. It is important to note that the constructivist interpretivist learning theory is a view in which the teacher creates a conducive academic environment so that their prior knowledge of a subject might be used to teach them (McLeod, 2023). The constructivist interpretive theory proposes that "the teacher's primary responsibility is to create a collaborative problem-solving environment where students become active participants in their learning" (McLeod, 2023). This paradigm is necessary for my research because I took the learners out and we traveled from S'Diphola Secondary School to Cosmo City Primary School in Cosmo City. I taught the students about travel using concepts like distance, velocity, speed, etc. I asked them to think about space travel and the future of traveling using sophisticated transport systems like rockets and airplanes.

The study also used a qualitative research method because the teacher I supervised asked the students a few travel questions. Their views were recorded and further discussed in sub-groups, I created among the students. In other words, interviews and questionnaires were administered to the students, thus resulting in a progressive recording and observation of the learners' responses. The learners were assigned to consult sources explaining other travel concepts, such as acceleration, movement, gravity, speed, velocity, distance, etc. The aim is for them to analyze the views of other authors about the connection of those terms with their conception of travel. Two other teachers who teach STEM education at Cosmo City Secondary School were also interviewed. Their interviews are centered on the availability of Information Computer Technology (ICT) tools at the school that are supposed to be used for teaching STEM. The significant items centered on the teachers' interviews are the availability of a computer lab in the school, SMART boards, projectors, television, satellite systems, radio, cell phones, and transmitting software.

Finally, the data in this research were obtained based on the questionnaire structure developed in Appendix A. The researcher applied the constructivist approach, where learners were given ample opportunity to think, create, and design various ideas using the subject of travel. The interview or discussion was conducted while the learners and the two teachers walked from S'Diphola Secondary School to Cosmo City Primary School. The learners were allowed to relax and ponder the questions while walking. At the beginning of the class, the teachers went from one group to the other, listening to the student's discussion about all the questions. The teachers listened and noted their views. On a second note, the teachers asked all the students to come together into one group with their notebooks. Generally, the research is an open-ended questionnaire where learners can think about various responses or answers to the questions raised. All these were done under the supervision of the researcher.

### Data Analysis

For a proper understanding of the subject in focus, there is a need to divide the responses obtained in an arranged format that aligns with the nature of the questionnaire divided into different sections. The analysis is explained in a section to tally with the division of the questionnaire. The questionnaire has questions from sections A to F; the responses are obtained below.

Section A: There were ten learners. A single female and nine males.

Section B: This section introduces the general concept of travel. The term is a familiar or popular term for all the students. They all responded that the travel was fun, though some felt it was a long-distance walk. They mentioned words synonymous with travel, including movement, speed, acceleration due to gravity, motion, etc.

Section C: The learners guessed the distance between the two schools was 500m to 600m. They interacted on the subject of converting the meters to kilometers. They thought airplanes had different routes than cars; thus, both travel machines would cover different distances from S'Diphola to Cosmo Primary School. The concept of velocity ( $v = a/t$ ) became relevant and they calculated time and direction as significant components in determining the distance between the two schools traveled by foot, airplanes, and cars. Each student was allowed to plot a graph using the map of Cosmo City that explains the travel routes between both schools using the formula distance speed  $\times$  time.

Section D: The target is scientific knowledge about travel, which involves critical thinking, inquiry, and an idea of life outside the earth. The learners generally thought that an astronaut travels to space. They taught that traveling to space is possible because spaceships were designed to subdue the force of gravity. Students were challenged to find the materials attached to airplanes or spaceships that allow those objects to overcome the force of gravity. The students discussed factors that made them think that humans do not exist on other planets except the earth. They mentioned factors like the absence of oxygen for inhalation, the absence of plants on other planets, and the absence of gravitational force, and they thought that the air, the soil, and other essentials for sustaining life might be inadequate or absent away from the earth. The learners made various assumptions and predictions about other planets, including the existence of aliens, while others refuted them. The idea of creation and evolution was mentioned by two of the learners and while some supported creation, saying only the earth is meant for humans to live, others believed that evolution is ongoing and that other spaces or planets are not yet to be discovered by humans.

Section E: The students could not conclude why certain machines travel faster than others, but the discussion was robust to the point that they imagined what objects or engines are placed in machines that make them able to travel slowly or faster. On a second note, I asked them to design or create anything they think can travel. They drew various lines and imagined what could be made or added to make an object move independently. They thought about engines, transmissions, driveshafts, gears, etc.

Section F: Many fast-moving objects like airplanes, electric cars, trains, and more were mentioned. Humans are thought to be limited, unlike machines programmed to work 24 hours and many more. Learners were left with dazzling questions, thinking about the objects or parts that make airplanes or cars travel faster.

Teacher's Role in Supervising Learners: The teacher guided the learners in their discussion to avoid going off-point. Students were told to write some crucial points in their discussions. They were told to read and think about the subject of travel repeatedly. Observation, motivation, and recording vital points became significant roles in the research. The study was student-centered.

Teachers' Responses from Interviews: The researcher observed and took records of the two teachers interviewed to ascertain their abilities and motivation in teaching STEM. The researcher observed that Cosmo City Secondary science students have a computer, but all ten computers are outdated and non-functional. One of the teachers has a personal laptop, unlike the other. The school does not have projectors and SMART boards. This has limited the teachers' agility in teaching effectively in STEM education.

### Results and Discussion

In some quarters of Cosmo City, there is a general view that science subjects are difficult and meant to be studied by females only. The teacher asked the students specific questions about meaning, calculation of movements, and an inquiry into the future of travel that is connected with figures in association with speed. Cosmo City is in Ward B of Johannesburg. There are three public

schools in Cosmo City. The study is also centered on a report or responses from two teachers who were interviewed about their challenges in teaching STEM, especially those that pertained to the availability of ICT materials that can encourage STEM education at Cosmo City Secondary School. Poor funding and overcrowding have been major features for many schools in poor South African communities. Cosmo City is not the exception as the absence of science teachers. Hyslop (1999) noted that overcrowding among African students led to inadequate resources (p. 152).

The data used were obtained from, first, the reports of the interaction with learners, secondly, the assignments or research work given to the learners to do in groups and individually. Thirdly, the researcher made many observations of the students regarding how they think or hypothesize over certain issues like survival out of space and the creation of fast-moving objects. From the data or information collated, it can be said that the subject of travels among grade 10 science students in S'Diphola Secondary School Cosmo City is familiar. The learners learned that while they can calculate speed and obtain figures about travel, they could also guess or hypothesize on the subject of designing moving objects or imagine the future state of travel where humans can use more complicated items to aid travel. The design involves the development of programs or software's that could serve collaboratively with current moving machines or be an alternative means of travel compared to current moving machines. For the development of the program or software that might be used to develop or design current and/or other alternative moving objects, the teacher encouraged the learners to learn to apply and use software connected with travel.

In addition, some computer games can help in this regard. The research results indicate that there is yet to be a concrete development by the South African Department of Basic Education to develop a STEM subject curriculum that can assist learners in impoverished communities. On this subject, Banda Benson mentioned that there is an urgent need to address Africa's challenges in STEM education by developing an appropriate curriculum for our learners otherwise:

If this is allowed to continue, there will be misapplication and implementation of the Science curricula, STEM education cannot be attained, and African education will continue failing to prepare youths for the labor market requiring STEM skills. This means that it would be difficult to produce a STEM learner who is a critical, creative and analytical thinker, relates thinking with real-world situations, is a problem solver and a responsible citizen who will bring about economic development in the African countries (Banda 2021, p. 16).

Furthermore, the researcher depended solely on the learners' prior knowledge of travel. Further opportunities were given to the learners to ponder, think, and develop a program that can aid travel. The outcome of the research specifically points out that grade 10 science students at S'Diphola Secondary School Cosmo City believe humans can enhance the future of travel by creating sophisticated machines as technology continues to evolve. The seriousness and cooperation of the learners in sharing their knowledge with the teacher and other learners on travels suggest that the outcome of the research can be relied upon within the context of Cosmo City. Most black-dominated townships within Gauteng Province may have a similar idea and outcome with regard to the perception of females studying science, the view that travels can be studied using day-to-day references and that the knowledge of STEM can be applied in schools that have similar standards as those of S'Diphola secondary School Cosmo City.

Although literacy and numerical scores for white people are higher than those of black people in schools meant for blacks (Hoffman et al., 2016), this research shows that if STEM education is taught even among poor black communities, the knowledge can be comprehended and accepted by all irrespective of the background of the learner. More so, the researcher demonstrated that the learning theory of the constructivist-interpretive approach could be applied in a society where learners are allowed to think and create ideas and knowledge

independently so they can solve life problems (McLeod, 2023). The researcher allowed the learners to see and think about travel. They were allowed to imagine and create ideas pertaining to fast travel and the future of travel. The learners' imagination was boasted, suggesting that with proper teaching skills, learners can learn beyond ordinary imagination.

### Summary

The research dealt with the constructivist interpretivism view according to which skills in learners can be tapped when the teacher mainly facilitates and guides learners towards achieving a specific academic goal. In this study, the researcher gave the learners ample opportunity to develop ideas and be creative in designing a mind map on the subject of travels in connection with STEM subjects.

### Contribution

The researcher indicated that even learners living in poor communities in South Africa could equally have the ability to explore scientific knowledge beyond a reasonable doubt if they are well-guided and despite their lack of proper ICT lap. Although the concept of allowing learners to think for they is highly debated among some teachers and scholars, this research shared that learning can be possible using the constructivist theory of learning. The researcher combines various STEM subjects to teach a practical skill to the learners using the subject of travel.

### Limitations

A supporting laboratory, resources, and teachers to support STEM education is a challenge. S'Diphola High and Cosmo City Secondary School do not have adequate ICT gadgets to support STEM education teaching. There are few or no resources that specifically guide teachers in implementing STEM education for learners, especially in underprivileged communities like Cosmo City.

### Conclusion

STEM education is essential for contemporary society because it prepares learners for the workplace. It enhances critical thinking, creativity, digital literacy, and independent learning skills, improves communication, and allows learners to solve life's existing problems and challenges. The researcher found out that when learners are well-taught using day-to-day references or examples, it is possible to understand and apply STEM education irrespective of the socio-political background of the students.

### Recommendations

The training and retraining of teachers to teach STEM subjects is relevant. School libraries and laboratories should be equipped to meet the contemporary need of integrating science-based knowledge such as STEM. Government-based educational agencies and relevant NGOs should assist in providing these necessities, especially in underprivileged communities. A curriculum that addresses the challenges of STEM education in South Africa should be developed as a matter of urgency.

### Ethical Considerations

This article followed all ethical standards for research without any intention to hurt the feelings or beliefs of any individual or group.

### Data Availability

Data sharing does not apply to this article as no new data were created or analyzed in this study.

### Disclaimer

The views and opinions expressed in this article are those of the author and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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Received: 21 November 2023  
 Revised: 27 December 2023  
 Accepted: 11 January 2024

## Appendix A

Research Topic: The Role of STEM Education in Teaching and Learning in South Africa's Underprivileged Societies

## Section A: Student's Information

Name/Surname.....(Optional)  
 Class.....(Optional)  
 Age.....(Optional)  
 Gender.....(Optional)

## Section B: Creating a Meaning for Travel

1. We just took a walk from S'Diphola Secondary School to Cosmo City Primary School; how do you feel and how would you describe our walk?
2. What is the meaning of travel?
3. What other words can be used for travel, or can you give some synonyms for travel?
4. Why do people travel?
5. Which countries or heritage sites would you like to travel to?

## Section C: Travel and Mathematics

1. What is the distance between S'Diphola Secondary School and Cosmo City Primary School?
2. Why will an airplane or car move faster from S'Diphola Secondary School Cosmo Primary School.
3. Think about the direction of the plane and car routes. Can you plot any graph in this regard?

## Section D: Travel and Science

1. What is the duty of an astronomer?
2. How is space travel possible?
3. Can humans exist in outer space?
4. Are there certain planets suitable for human existence? Discuss.

## Section E: Travel and Engineering

1. Why are certain machines able to travel at longer distances?
2. Can you imagine and design any object that can also travel?

## Section F: Travel and Technology

1. List some items or objects that are non-living things and can travel at longer distance.
2. Why can't humans travel longer distances on their own like some mechanical objects?
3. Are there some parts of the airplane or fast-moving space objects that enable them to rise above the force of gravity? Discuss

## Questions to Teachers

Name/Surname..... (optional)  
 Subject Taught.....(optional)  
 Age.....(optional)

Gender.....(optional)

**1. STEM education is a popular subject in South African schools.**

- A. Agreed
- B. Strongly Agreed
- C. Disagreed
- D. Strongly Disagreed
- E. Undecided

**2. ICT gadgets are primary in the teaching of STEM education.**

- A. Agreed
- B. Strongly Agreed
- C. Disagreed
- D. Strongly Disagreed
- E. Undecided

**3. Cosmo city secondary school is properly equipped with ICT gadgets.**

- A. Agreed
- B. Strongly Agreed
- C. Disagreed
- D. Strongly Disagreed
- E. Undecided

**4. Our school enjoys enough support and motivation to teach STEM.**

- A. Agreed
- B. Strongly Agreed
- C. Disagreed
- D. Strongly Disagreed
- E. Undecided

**5. There are enough computers available for teaching ICT in connection with STEM**

- A. Agreed
- B. Strongly Agreed
- C. Disagreed
- D. Strongly Disagreed
- E. Undecided