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Physical Science Teachers' Understanding of Strategies for Teaching Critical Thinking in Mpumalanga Province

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Abstract. This study aims to examine the Physical Science teachers' understanding of the concept of critical thinking and the strategies they employ in teaching learners to develop the competency of critical thinking in Physical Science**.** A purposive sample of 12 Grade 10 public school Physical Sciences teachers participated in the study. An exploratory qualitative study was conducted among these teachers who were teaching Physical Sciences in Mashishila circuit, Mpumalanga Province at the time of the study. Data was collected through a naïve sketch which comprised of open-ended questions. Analysis of the data using the content analysis revealed that the teachers understood critical thinking as a way of observing, analysing, and assessing any situation before them in order to solve it. However, the participants left out the fact that critical thinking is self-corrective and that the learners need evidence to support their decisions to arrive at solutions for each problem statement. Although the participants showed an understanding of critical thinking, they reported teaching strategies that did not show a relationship with the development of critical thinking. There is a need for professional workshops to train the teachers on the strategies to teach critical thinking. This paper forms the basis of an ongoing study that will develop strategies for teaching critical thinking to Physical Science learners.

Keywords: understanding; critical thinking; instructional strategies; qualitative study; physical sciences

1. Introduction

Educational scholars have over the years shown growing interest in conceptualising, defining, and making assessments on skills competencies necessary for excellence as an outcome of a student's learning (Alazzi, 2008). By the same token, the education system has always aimed to produce a person who

will be able to fit into society. This is based on the understanding that one's quality of life depends largely on the quality of the way one thinks (Paul & Elder, 2020). As a result, the general concern of education has been to produce educated citizens with the ability to think critically (Alazzi, 2008). This is consistent with the views of Burke (2010) who reported that the course work done in science by college students required them to use critical thinking on a daily basis in the laboratory or through problem-solving. As a result of such findings, the Jordanian National Education Conference identified a need to increase the number of high school graduates that could think critically, communicate effectively, and solve problems (Alazzi, 2008). Fundamental to educating the subject of science, from processes to general content, amongst others, is equipping learners to be adaptable, agile, and to think out of the box. Learners need to be taught creative ways to engage collaboratively with others by accepting and tolerating the diversity of people's thoughts together with their own way of thinking. Learners are thereby being equipped to respond to uncertainties and the ever-changing landscape of the digital world (Aktamis & Yenice, 2010). Central to modern-day technological advancements, the balance of facts through in-depth analysis or evaluation is one of the significant developments of the mind of individuals to engage positively in the activities of the world (Bag & Gursoy, 2021). This is consistent with the views of Burter et al. (2017) who reported that students who have developed a critical thinking ability are likely to have fewer challenges in the future than those without.

In South Africa, one of the aims of the curriculum is to produce learners who can apply critical and creative thinking in decision making (Department of Basic Education [DBE], Curriculum and Assessment Policy Statement [CAPS], 2011). This is in line with what has been the major concern of the 21st century, namely that critical thinking is one of the pre-requisite characteristics every student should have (Prayogi et al., 2018). Consistent with today's major expectations of employers, critical thinking helps the learners to sustain global welfare and remain relevant as well as transformational in today's organisations where they will be required to undertake business judgment where little or no clarity often exists (Mok & Yuen, 2000; Nold, 2017).

In science education, critical thinking is being emphasised for scientific development and also for developing democratic behaviours in the personal, political and cultural sphere (Yacoubian, 2015). The ability to think critically refers to the process of identifying the areas of an individual's problematic thinking, and working on them in order to change the thinking for one to be able to reason in a more rational and logical manner, thereby justifying one's thought processes (Paul & Elder, 2020).]. As such, critical thinking is essential to the individual's success and also helps people to defend themselves to a world that has so much information and too many people trying to convince them (Taimur & Satter, 2020). For example, in the era of the 4th industrial revolution, drastic changes emanating from aggressive technological advancements tend to impact the outcomes of student learning (Burtler-Adam, 2018), especially if teachers continue to rely on traditional teaching methods for science subjects (Oke & Fernandes, 2020). Accordingly, critical thinking is an essential tool that students, workers, and citizens can use to perform competently in such a rapidly changing world.

Despite South Africa's having such an intended curriculum, the level or standard of its education, especially from grade 10 upwards, could not go without scrutiny. Notably, some industry bodies or institutions in South Africa such as the South African Institute of Physics [SAIP] (2013) have suggested that the science education of these grades was of a very low standard; this hindered the students' eventual entry into tertiary institutions such as universities. This observation only confirmed what had been revealed by a study by Lombard (2008) that was carried out at one of the South African universities. The study was aimed at determining the coherent transmission of the educator's understanding of the notion of thinking critically to the learner. The findings revealed that most of the secondary and high school education students did not excel in the tasks that assessed critical thinking competency. The lack of critical thinking in these students is attributed to the traditional teacher-centred teaching and learning methods which mainly prevail in the South African school classrooms. DiCamillo (2010) suggested that the teacher-centred approach deprived learners of critical and creative thinking. In a study on the preparedness of teachers to teach critical thinking, Lombard (2008) found that the large numbers of students' intakes at the institutions constrained the nurturing of critical thinking in students. The Department of Basic Education, South Africa's National Education Evaluation Development Unit (NEEDU) (2013), reported that there was a correlation between the challenges or gaps identified in the learners at tertiary education vis-à-vis their inability to think innovatively and the absence of innovative teaching competencies in the educators' teaching methods. Furthermore, Peterson and De Beer (2012) also suggested that the weak performance of the learners was also attributed to many teachers who did not have the required pedagogical content knowledge and skills regarding the curriculum which has undergone frequent changes. According to Yuan and Stapleton (2019), if the teachers' conceptual understanding is questionable, then they lack the competence to develop the learners' critical skill. The teachers' conceptual understanding of critical thinking influences the behaviour in the classroom (Choy & Cheah, 2009).

This research aims to determine the practising teachers' understanding of critical thinking in the Mashishila circuit in the Mpumalanga province, with a particular focus on Grade 10 Physical Science learners. The findings of this study add to highlighting the inadequacies of the teacher training institutions of South Africa in order to improve on the quality of teachers trained. The findings also help the practising teachers with the strategies that can be used for teaching critical thinking within the limits of inadequate resources which is a common occurrence in our South African public schools. In order to fulfil the aim of this study, the following guiding questions were utilised:

i. What is the Physical Sciences teachers' understanding of the term 'critical thinking?
ii. Which strategies do the Physical Sciences teachers use in teaching critical thinking skills to Grade 10 learners?

2. Literature Review

2.1 Physical Sciences Curriculum in South Africa

It has become an entrenched submission that in the Physical Sciences spectrum critical thinking is regarded as one of the core aspects of teaching the subject (CAPS, 2011). The South Africa education and training sector introduced the notion of critical outcomes towards an outcome-based approach to education; the result is the competency of having an effective solution-driven thought process in a dynamic society coupled with aggressive technology (Lombard, 2008). With the revision of the outcome-based curriculum the same concept of critical outcomes was carried through to the new curriculum known as the National Curriculum Statement (NCS) (DBE, 2011). In the same document, one of the aims of education was to promote individuals who can come up with decisions that resolve challenges using critical and creative thinking. According to the National Curriculum Statement of the Republic of South Africa - Further Education and Training Phase (FET), Physical Sciences Grade 10-12 aim to produce learners that can:

- *identify and solve problems and make decisions using critical and creative learning;*
- *collect analyse, organise and critically evaluate information;*
- *use science and technology effectively and critically showing responsibility towards the environment and the health of others; and*
- *demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation (DBE, 2011, p5).*

2.2 Defining Critical Thinking

In this section, the relationship of critical thinking with practical thinking and logical thinking is described. Many scholars define critical thinking as being composed of skills or abilities and dispositions (Ennis, 2016; Mason, 2008). The difference in the scholars' views is the way they present the various skills and dispositions which nevertheless represent similar meanings. Othman and Al-Hileh (2022) described critical thinking as being concerned with the learners' being able to give explanations that are closer to the truth about the topics being discussed. This ability reduces errors in misinterpreting the meaning of the content. The definition echoes the examples given by Norris and Ennis (1989) which implied the need for clear thinking involving interrogation inferences in order to come up with a concrete basis for the inferences, while also following the logical processes of critical thinking. Othman and Al-Hileh (2022) proceeded to outline the skills learners have to acquire to develop critical thinking such as the ability to solve problems and to make logical judgement based on the evaluation of phenomena and information gained through research. This is to be achieved through acquiring skills such as analysis, inference, induction and evaluation. On the other hand, Moon (2008) suggested pointing out, making assumptions, clarifying ideas, and ascertaining the credibility of judgments of any claims as being related to critical thinking. Before one can be regarded as a critical thinker, one needs to possess certain dispositions which act as pre-requisites to critical thinking. The dispositions are, amongst others, that the critical thinker should be able to accept other people's views, not be quick to jump to conclusions, and lastly, the critical thinker should have bases for their actions and beliefs (Norris & Ennis, 1989). Mason (2008) gave examples of the ways in which learners need to be

engaged for them to develop critical thinking: learners should have an attitude that is critical, a mind that can accommodate different ways of thinking.

Paul and Elder (2013) considered "critical thinking" to be some in-depth inquiry into a particular idea with a focus on ensuring continuous improvement to the thought process giving rise to that idea. Similarly, critical thinking is methodical in that it requires diligently diagnosing the problem statement, systematically gathering information, organising and evaluating data for relevance based on trials and tests as well as mirroring to formulate scientific conviction (Scriven & Paul, 2007; Lipman, 1988). Emanating from these determinations, thinking critically as a line of thought is metacognitive, and is based on a myriad of measures and competencies which, over the years, have been established in the education discipline through study and research.

The idea of self-reflection means that one should vigorously review one's thoughts in terms of which the advantages and disadvantages of one's thoughts or actions are thoroughly examined before acknowledging that thought or action as an authority on the subject matter in question (Lipman, 1988). Self-reflection by the teacher will by implication be transmitted as the learners would be prompted to interrogate their teachers or fellow students on their beliefs, understanding, and the learners' proposed solutions to the subject matter in question, thereby correcting their weaknesses and faulty thinking.

A separate section follows that outlines definitive parameters under which the notion of thinking critically should be pursued.

2.2.1 Standards as a Basis to Judge Critical Thinking

The Merriam-Webster Dictionary online defined standards as a set of desirable activities, skills, actions, or performance that are set as a measure of evaluation. The above discussions have shown that the progression of abstract thought as a competency is centred on the continuous improvement of the requisite prowess and characteristics. Being able to perform any given task with adroitness requires a clearly defined measurement criterion. Lipman (1988) says that a skill cannot be defined without a set criterion. Against the above background, in order to arrive at a certain scientific conclusion, there should be concrete guidelines or defined measurement criteria upon which one's contentions are based. As a result, a number of scholars have undertaken detailed reviews of the varying degrees of abstract thinking credentials in physical science literature.

Lipman (1988) submitted that making a determination is a process in terms of which one takes into account defined principles, prescriptions, and regulations which are applicable to that subject matter. Some of the prescriptions identified are lucidity, validity/reliability as well as profoundness (Paul & Elder, 2013). These standards are necessary for one to develop an intellect that will enable one to live a rational life. If, for example, one is given a clear statement, they will be able to determine whether it is accurate or relevant to what is being addressed at that moment. Therefore, suitable strategies are needed for the development of a critical mind. One can only check for the accuracy of the statement if it represents things as they are. The standards lead to the development of suitable strategies

necessary in the progression of free-thinking in teachers imparting skills in Physical Science education to students in South Africa.

2.2.2 The Role of Critical Thinking.

The ever-changing world requires people e with critical-thinking skills for solving problems easily and making decisions quickly (Facione, 2015). Critical thinking allows individuals to interrogate unfamiliar situations, ask questions, solve problems and make decisions in a well-organised and rational way of thinking (Zoller et al., 2000). Similarly, Simister (2004) expressed the view that critical thinking helps learners to reach their full academic potential through a deep understanding of their surroundings, making wise decisions in their lives while respecting those around them, as well as being innovative in solving problems. It has also been found that learning critical thinking skills help an individual to be an effective reflective thinker (Higgins, 2015). Critical thinking is needed in many different situations in life for one to be successful in the academic world, in the world of work, and also for professional development. It enables individuals to acquire new information and interrogate events so that they have a more comprehensive and accurate understanding of events (Nosich, 2012).

In any work situation, learners need critical thinking skills for them to evaluate policies, people, and their institution as well as for them to be able to solve social problems (Hatcher, 2006). Evidently, there is the contention that skills development in critical thinking is necessary for academic outcomes of individuals as it enhances reasoning and problem-solving skills, thereby contributing significantly to an individual's success in life (Jamil & Muhammad, 2019) by making reasonable judgments in those situations. The successful development of critical thinking depends on teachers who have creative and critical skills based on a scientific perspective for them to be able to pass these on to their learners (Demir, 2015). These teachers will be able to use different strategies to reduce rote learning among learners. Rote learning, which is memorisation, has been considered one of the major challenges in/to? the development of critical thinking skills (Jamil & Muhammad, 2019). The following strategies from the literature have been suggested for the critical thinking skills' development of learners: active participation such as answering questions in groups, taking part in discussions, debating, problem-solving, and inquiry-based learning (Duran & Dokme, 2016). Demir (2015) mentioned engaging students, asking them questions, having discussions, participating in group activities, collaborating and self-evaluating.

Critical thinking as a process is also enriched by other methods of thinking as presented below.

2.2.3 Critical Thinking vs Practical Thinking

The role of critical thinking has been discussed in the previous section. In contrast to critical thinking, practical thinking occurs when individuals consider ways to adapt to their environment, or change their environment to suit them so that they would be able to pursue a specific goal (Practical Thinking: Definition and Examples, 2016). The main aim of practical thinking is to solve a problem using the knowledge a person has already acquired without necessarily gathering any new knowledge. This is opposed to critical thinking where one identifies and goes

through processes as outlined before to search for the root of the issue that causes the problem. The aim of the search would be to fix it so that it will not arise again or that it would open up other areas of investigation. An example when teaching Physics can be the various experiments that students conduct in the laboratory.

2.2.4 Critical Thinking vs Logical Thinking

Logical thinking uses reasoning in a way that assists individuals to come up with informed solutions. This is possible through a critical analysis of the situations, grouping similar information so as to produce solutions to the problems at hand. On the other hand, critical thinking uses logic to distinguish and evaluate accurate from inaccurate beliefs. Therefore, the experiments in Physical Sciences will teach the students scientific thinking. Scientific thinking follows a logical thought process based on hypothesis-making data.

2.2.5 Studies related to Teachers' Understanding of Critical Thinking

Studies have been carried out on the perception of teachers on critical thinking and the implications it has for the teaching of critical thinking. Alwadai (2014) conducted a study on the perception of 192 male teachers who taught elementary school. The study revealed that the majority of the teachers lacked the basic knowledge of critical thinking. As a result, these teachers did not value or practise critical thinking. A similar study was carried out by Al Ramis (2018) which examined five female Saudi Arabia university instructors' attitudes and perceptions towards critical thinking. The instructors had a low to no level of awareness of what critical thinking was all about. This became an obstacle to the teaching of critical thinking to the learners. Similarly, Zhang et al. (2020) conducted a study on the perceptions teachers of English as a foreign language in China. Although the teachers agreed that critical thinking was to be included in their curriculum, they lacked the professional knowledge of critical thinking and how to implement it in their classrooms. The teachers even indicated through questionnaires and interviews that they were teaching critical thinking; however, this was not evident in their teaching practice. All this indicates that although governments may declare critical thinking as a necessary skill in their policies of education, the implementation of the policy depends on the teachers' perception or understanding of critical thinking. As long as the teachers do not have the knowledge relating to critical thinking, the above studies revealed that it will not be taught.

3. Theoretical Framework

The research is anchored on the belief that critical thinking skills can be taught through appropriate teaching approaches (Zabit, 2010). Specific teaching strategies need to be employed in order to develop critical thinking skills (Snyder & Snyder, 2008). Critical thinking skills need teachers to create an enabling environment that supports the thinking activities (Rajendran, 2010; Mason et al., 2010). The thinking skills will be explicitly taught to the learners within the context of Physical Sciences. Central to this paper is a discussion on the processing of information, be it content analysis or structuring of exercises in class discussions by teachers in Mpumalanga Province. These signify their appreciation of the subject matter in Physical Sciences and the methods (transmission) they use to ensure competency of learners in absorbing the intellectual skill of "critical thinking".

4. Methodology

A qualitative approach using questionnaires and interviews has been used to answer the research questions in this study. The researchers' main aim was to establish the Grade 10 Physical Science teachers' understanding of critical thinking and the strategies they used to teach critical thinking. The approach was used to understand the teachers' perception and their methods of developing critical thinking in the secondary school learners they taught.

Ten (10) public schools, were selected as research sites from the Mashishila circuit in the Mpumalanga Province. These were, at the time of this research, fully funded in their day-to-day running by the South African government, through the Mpumalanga Provincial Department, the circuit schools are from the same geographical area. Mashishila circuit was sampled selectively for it was easily accessible.

Data was collected through self-administered open-ended questionnaires that were distributed to 12 teachers to explore their understanding of critical thinking and the methods they used to teach critical thinking among their secondary school learners. The questionnaires were open-ended to afford the participants an opportunity to express their views fully and to give an in-depth account of their understanding of critical thinking as well as reporting and relating their practices freely. The questionnaires included data on the teachers' qualifications, teaching experience in teaching Grade 10 Physical Science, and the different/various? approaches they used in teaching critical thinking. Since this study was part of an ongoing study, it sought to give the necessary qualifications needed for the teachers who eventually formed part of the main study. Each teacher was given adequate time to complete the questionnaire while the researcher waited to take them along with him. It was only in two schools where the researcher had to leave the questionnaires for the teachers to complete and then returned later in the day for collection. Permission to conduct the study was sought from the Mpumalanga Provincial Department of Education, and the Mashishila circuit offices before approaching the school principals. The principal at each school granted permission based on the documentation from both the Provincial Department and the Mashishila circuit offices.

The data referred to was processed immediately on the day it was collated. In evaluating the information gathered, the data was reviewed and patterns from that information identified at the same time. It was classified into the different interpretations of the teachers' understanding of critical thinking and also into the different strategies suggested by the teachers. The analysed data was verified by two colleagues who checked on the accuracy of the captured information. Only two teachers were interviewed to verify the accuracy of some information they had provided on their questionnaires.

5. Results

Data from this study were presented in tables. Table 1 shows the analysis of teacher qualification while Tables 2 and 3 show the qualitative data on the teachers' understanding of critical thinking and the strategies used to teach critical thinking respectively.

5.1 Teacher Qualification

Table 1: Analysis of teacher qualification

Qualification	Subjects	Teaching experience (years)	Status of teacher
B Ed	Biology	24	NQ
B.Ed. Hons, FET	Physical Science	3-10	Q
BSc & B.Ed.	Physics & Chemistry	3-5	Q
BSc & PGCE	Physics & Maths	2	Q
BSc	Physics/ Chemistry/Bio	0	NQ
BSc	Pure & Applied Chemistry	3	NQ
MSc, BSc & Bed	Physics & Chemistry	7	Q
M Comm, IT	Maths & Physics	4	NQ

Key: Q means Qualified to teach Grade 10**; NQ** means Not Qualified to teach Grade 10

Table 1 shows the qualifications of the 12 teachers who were teaching Physical Sciences in the schools in the Mashishila Circuit. Owing to the lack of qualified physical science teachers in the Mpumalanga province, those with academic degrees related to science, even if they were not trained as teachers, were also engaged to teach Physical Sciences. These untrained teachers, however, underwent some inductive workshops within-subject panels for them to teach Physical Sciences. This enabled them to provide information in relation to their understanding of critical thinking. From Table I, seven teachers had the relevant qualifications to teach Physical Sciences. However, for this study, only six teachers could qualify to participate in the study since only teachers who had three or more years of teaching in Grade 10 Physical Sciences could be included. These six teachers were trained to teach Physical Sciences and were deemed to have an adequate understanding of the expectations of the Physical Sciences curriculum.

5.2 Teachers and Critical Thinking

Table 2: Teachers' understanding of the term "critical thinking"

Teachers' explanation
T1.When observing phenomena, one should ask why it has happened and try to find the answer for it
T2.Think broadly with regards to a given phenomena
T3.Thinking in depth involves and promotes understanding, analysis, and evaluations
T4. Way of thinking about any subject or content in order to improve the quality of one's thinking through skilfully analysing assessing and reconstructing it
T5. Problem-solving
T6. Logical understanding of the connections between ideas and be able to solve different problems
T7. Creative thinking alone, to think yourself anything and be able to create something on your own

Table 2 shows that the teachers understood critical thinking as a way of "observing phenomena and ask[ing] why it has happened and then try[ing] to find the answer" (T1) and "to think broadly, in-depth or out of the box" (T2). This process involves "analysis and evaluation" (T3), and promotes understanding through incorporating real-life situations. Participants also indicated that critical thinking was a "way of thinking about any subject or content in order to improve the quality of one's thoughts through skilfully assessing, analysing and reconstructing it" (T4). The other frequently stated understanding was that critical thinking was the "ability to reason and then apply the thinking to problem-solving" (T5). Critical thinking was also expressed as the "logical understanding of the connections between ideas and being able to solve different problems" (T6). Another explained critical thinking as "creative thinking alone to think to yourself in order to create something on your own" (T7). This statement was a direct translation from vernacular which referred to an individual who would think of some idea and then create something new from that idea. This shows that those teachers equated creative thinking to critical thinking; although the concepts are related, they are different. Before discussing the teachers' understanding of critical thinking, the different strategies the teachers gave for developing critical thinking are examined.

5.3 Teaching Strategies

Table 3: Strategies for teaching critical thinking

Strategies
Use of questions – higher order
Experiments: Demonstrations on how to solve problems, Laboratory methods
Investigative type problems/ Research work
Group work- discussion, debates
Tests: long questions, use of previous question papers
Media: overhead projector, Internet, textbooks
Expose learners to the practical world of science
Lecture/Demonstration
To develop creativity, encourage to categorize, classify, compare
Develop classroom assessment tools

Table 3 shows the different activities that were suggested as the strategies by the participants for teaching critical thinking. The majority of the teachers proposed the use of questions. These included four who posed higher-order questions and two who asked investigative questions. Four teachers showed that they used experiments through laboratory work although they did not specify what experiments they would be doing to teach critical thinking. Seven teachers also indicated that group work was another strategy used for teaching critical thinking through discussions and debates. Tests were also used whereby the teachers set long questions for learners to explain using their own words. The other common strategies included lectures, demonstrations, the use of media such as overhead projectors and the Internet, and textbooks.

6. Discussion

It is significant to indicate that the definition of critical thinking has been debated for a long time in different education forums (Evans, 2020). Notwithstanding the above submission, many philosophers in education have expressed that critical thinking is of paramount importance to every person in society as it contributes to one's ability to make informed judgments on public matters (Pradanaet al., 2020).

Critical thinking involves the ability to produce knowledge and formulate a viewpoint, to evaluate, classify, analyse, draw relationships and make conclusions (Devi et al., 2015). Paul and Elder (2013) and Liu et al. (2014) go further by describing analysis as an effort to improve one's way of thinking, including making effective decisions. The findings in this study show that the teachers defined critical thinking as activities or skills to be acquired by learners. This is illustrated by one of the participants who defined critical thinking as "a way of thinking in order to improve one's thinking through skilfully analysing, assessing, and reconstructing" (Table 2). The participant showed some understanding of critical thinking by explaining that "this can be achieved through making connections to real-life situations". What this implies is that critical thinking is a process that takes place in the mind. The mind examines all that the individual encounters daily and tries to understand this in relation to one's experiences with the world and the people with whom in one is in contact (Demir, 2015). The participants also explained the notion of abstract thought as the aptitude to organise a person's life of reasoning rationally and find solutions to problems. Critical thinking in science, of which physical sciences is one field, is associated with the practice of science and education. It plays a role in helping an individual to use critical thinking responsibly in developing science and technology for the benefit of society.

Inamullah et al. (2016) point out that critical thinking in the context of science education and education in general is essential for it promotes science to be part of the peoples' daily lives by examining their cultural and political contexts. This helps the people to understand democratic societies and promote an understanding of the scientific content, for example, the subject of climate change. It is from these scientific developments that social problems emanate, such as the threats from nuclear war. These social ills then form a crucial role in educational institutions through moral and ethical values, and the promotion of critical thinking to solve these issues. This is also in line with the view of one of the participants, who explained critical thinking "as the understanding of logical connections between ideas and being able to solve different problems'' (Table 2). Lau and Chan (2015) echoed the participant's explanation of critical thinking by defining it as the ability to think rationally about what to do or what to believe in order to promote problem-solving skills in the learners. As suggested by the participant, one can ask the learners to work on a project such as water purification whereby the learners have to find out how this is done and then present this to their class. This then needs teachers who can see events from different scientific perspectives for them to help learners to think critically. However, this calls for tertiary institutions to train such a cadre of teachers who can think critically. Realising that there are already practising teachers who have

not been trained to teach critical thinking, this calls for the Provincial Education Department to organise training workshops for the teachers. In these workshops, they will discuss with the teachers the 'working definitions' which will be used as the basis for the teaching strategies for critical thinking.

Other teachers referred to critical thinking as "creative thinking alone about a subject" and "to think for yourself and be able to create something on your own". At this point, there is a need to point out that critical thinking and creative thinking are not the same but that one needs to think critically in order to be creative. There are also teachers who defined critical thinking as "thinking in depth which involves and promotes understanding" (Table 2). This understanding of critical thinking is similar to the explanation given by Pakistan teachers in a study by Jamil et al. (2021). The teachers defined critical thinking as "knowledge with deep thinking…reasoning behind knowledge." The above discussion revealed that the participants in the current study had an understanding of critical thinking.

When asked what strategies they used to teach critical thinking, the participants listed "use of questions, use of higher-order questions in experiments, and also investigative questions". These strategies are relevant for promoting critical thinking with the teachers using a variety of questions for the promotion of critical thinking in the classroom. However, most of the participants did not explain how the strategies given promoted critical thinking except for one participant who explained his views as follows:

> *I try the strategies given by being as practical as possible where applicable and I use real-life examples when explaining. I try to look for a question or discussion that promotes critical thinking and would normally have a discussion with peers. I look for a project such as how to purify water or recycling of paper and hence learners have higher-order questions they are given to answer.*

This is in agreement with the idea that critical thinking in science is the practice of evaluating, careful, rigorous testing, problem solving and finding appropriate solutions to problems, thereby linking critical thinking and science (Inamullah et al. 2016). Furthermore, higher-order questions and multiple questions in the classroom promote critical thinking.

Group work was another strategy that was used in conjunction with the questioning strategy as is illustrated by one of the participants. The participant illustrated how the strategy was going to be followed as follows:

> *Give learners questions that will require them to use their own words to explain what certain laws really mean and how they are used on an everyday basis.*

Dallimore et al. (2008), in support of the above strategy, found in their study that group work facilitated effective class participation, resulting in deep learning and development of critical thinking.

Testing was another strategy that was stated where two types of tests were administered. The learners could be given class tests where long questions were set and another where the learners had to answer questions from as many past

question papers as possible. The long questions would enable the learners to express themselves. However, it is not clear whether these questions could either be testing understanding of the taught concepts or whether they could help to develop critical thinking. The general observation is that most of the past examination questions test mainly factual information. In this study, the participants did not elaborate on how they were to use these past question papers for the development of critical thinking. No clear-cut explanation was given as to which of the questions they emphasised. Only one participant gave an explanation of the purpose of the test as follows:

> *I basically set a class test that consists of long questions that require critical thinking*.

This finding is consistent with the views of Duran and Dokme (2016)) who assert that groups working on the changes to improve science, including physical sciences learning, have recommended the teaching of science through inquiry and implementing a science curriculum that develops critical thinking in students. Such recommendations are what compelled the implementation of the new curriculum for countries such as England and Wales, the United States, and South Africa.

7. Conclusion

The study results revealed that the participants understood the concept of critical thinking. They described critical thinking as a way of observing, analysing, and assessing the situation before them in order to solve it. In addition, the participants defined critical thinking as a thought process that results in examining, weighing up, and relating the knowledge gained to find a solution to the question at hand. However, the teachers did not emphasise that critical thinking is self-corrective or that the learners needed to provide evidence in support of their decisions to arrive at solutions for each problem statement.

The study also highlighted the strategies put forward by the participants that included reliance on combined effort, printed documentation, practical experiments, brainstorming or sharing ideas, and literature. These findings indicate that critical thinking can be taught but only by a teacher who has been trained to think critically. However, the strategies put forward by the teachers for developing critical thinking skills did not clearly demonstrate the relationship between the identified strategy and the development of critical thinking skills as a resultant effect of such a strategy. For example, strategies for concept formation and inquiries into the existence of a factual understanding of physical sciences by learners were suggested by the teachers without any articulation of how these strategies furthered critical thinking skills. The literature points to the fact when students learn Physics, it gives them tools to investigate nature and be able to analyse and make sense of the environment surrounding them (Mitrevski, 2019). This author further pointed out that Physical Science provides a foundation for students to acquire logic, critical thinking, and problem-solving and decision-making skills using the acquired principles and concepts to explain the different phenomena they encounter in their life.

The current study has also managed to show that there is a gap between the teachers' understanding of critical thinking in teaching Science and the implementation of the strategies that can develop critical thinking in the learners. However, given that this paper is an outline of an ongoing study, the strategies for teaching and imparting critical thinking skills will be discussed in detail as the research of the ongoing study progresses.

8. Recommendations and Further Research

Based on the presentation of the discussion and findings of this study:

i) the Provincial Education Department should present workshops that discuss critical thinking and how it can be taught in Physical Sciences to cater for those who were not trained, and

ii) the ongoing study should be able to assess the effectiveness of the strategy used in teaching critical thinking.

9. References

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Appendix 1

Questionnaire for Physical Science teachers

Dear Colleague

Instructions:

Please write the responses to the questions on the spaces provided.

Gender…Male/Female

Indicate your qualifications …….

Major subject …… Subject(s) taught …….....

What class are you currently teaching?.....

State the number of years you have taught Grade 10 Physical Science…….

1. With the Physical Science curriculum being taught, what do you regard as the major skills the students will have at the end of the year?.....
   …….
   …….
2. What does the Physical Science curriculum expect the student to be able to do? ……..
   …….
   …….
3. What do you understand by the term "critical thinking?"……
   ……
   …….
4. What strategies do you use to teach Physical Science? …….
   ……
   ……
5. What methods do you specifically use to teach critical thinking?
   ……
6. What other strategies would you recommend for teaching critical thinking to Physical Science learners in Grade 10?.....
   ……
   …….. .
7. What more information might you add to the teaching of critical thinking in Physical Sciences? …….
   ……..
   ……..
   Thank you.