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The Effects of Case Study Teaching on Learners' Critical Thinking Skills in Physical Sciences Classrooms

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ABSTRACT: The aim of the study was to investigate the effects of case study teaching on learners' critical thinking skills in Grade 10 Physical Sciences classrooms. A non-equivalent (pre-test and post-test) control-group quasi-experimental design was adopted for the purposes of this study. The sample consisted of 122 learners from four schools (70 learners from two rural - 29 for experimental group and 41 for control group) and 52 from two urban schools (30 experimental group and 22 control group). A multistep sampling process was implemented in selecting the participating schools. Two schools were treated as the experimental groups and the other two as control groups. The intervention in the experimental group was case study teaching, while in the control group the traditional lecture method was implemented. The results of this study indicated that case study teaching improved learners' critical thinking skills and that the urban learners' critical thinking skills improved three times more than that of their rural counterparts. The results also indicate that there is no significant difference in the way case study teaching improved the critical thinking of the female participants compared to how it improved that of their male counterparts.

KEYWORDS: Case study teaching, Critical thinking skills. Physical Sciences, Context-based learning, Communicative action, Social constructivism

INTRODUCTION AND BACKGROUND

Developing learners' critical thinking skills is one of the main aims of science teaching (Bailin, 2002). This is also true in the South African context as Curriculum and Assessment Policy Statement (CAPS) for Physical Sciences prescribes that Physical Sciences teaching should equip learners with high levels of scientific-inquiry, critical thinking and communication skills on top of the required scientific theory (Department of Basic Education (DoBE), 2011). The development of critical thinkers within school contexts implies that classroom practice needs to be restructured to assist learners to acquire all the requisite skills to advance in science and concurrently feel confident to pursue science related careers at post-secondary school level (Tlala, Kibirige, & Osodo, 2014).

Evidence suggests that the quality of science education, as measured through critical thinking skills, is far below par. Critical thinking skills of secondary school learners seem not to improve as their grade levels progress and a plausible explanation is that critical thinking skills are not taught at secondary school level (Mabruroh and Suhandi, 2017). As a result, secondary school graduates enter post-secondary school science classrooms with inadequate critical thinking skills (Shaughnessy, Varela, & Liu, 2017) and this is also applicable in the South African context (Govender & Moodley, 2012; Spaull, 2013). In South Africa, on average, more than 60 % of the learners who wrote the Physical Sciences National Senior Certificate (NSC) examinations from 2010 to 2016 obtained a mark below 50 %. This further endorses the fact that learners are only able to answer lower order questions (levels 1 and 2 on Bloom's taxonomy) (DoBE, 2016). Leen, Hong, Kwan and Ying (2014) bemoan a general lack of policy clarity in terms of the route that education departments should pursue to address the teaching of critical thinking skills at secondary school level.

The current challenge in basic education is identifying a pedagogical strategy that incorporates the teaching of the subject content and critical thinking skills (Dagar & Yadav, 2016). In the meantime, Physical Sciences teaching in South Africa and globally is mainly teacher centred. Teacher centred didactics are not useful in developing learners' critical thinking as they reduce learners to passive recipients of knowledge (Zivkovic, 2016). A lot of work still needs to be done in identifying effective pedagogy for the incorporation of critical thinking skills into the teaching of physical science (Shaughnessy, Varela, & Liu, 2017).

Although critical thinking skills are central in defining educational goals of any education system (Dagar & Yadav, 2016), there is little effort to explore effective ways of integrating the teaching of critical thinking skills into the teaching of subject content at the

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secondary school level (Alsaleh, 2020). Palpably, there is a gap in the teaching of critical thinking skills at the secondary school level across all the spectra of subjects. Studies need to explore effective strategies to incorporate the teaching of critical thinking skills in the teaching of subject content knowledge (Alsaleh, 2020). Presently, there is limited focus on the teaching of critical thinking skills in Physical Sciences classrooms at the secondary school level (Alsaleh, 2020). On the other hand, case study teaching was found to be useful in enhancing post-secondary school students' critical thinking skills in non-science subjects. There is, however, a general absence of empirical evidence on the effects of case study teaching on secondary school Physical Sciences learners' critical thinking skills. This study is a step in the right direction in that it attempts to identify effective pedagogies that incorporate the teaching of critical thinking skills in the teaching of Physical Sciences and to stimulate debate on the development of critical thinking skills and the use of case study teaching in Physical Sciences at secondary school level to enhance critical thinking.

Since the effects of case study teaching on learners' critical thinking in physical sciences at the secondary school level has not been adequately investigated this study is crucial to enhancing our understanding of how case study teaching could be implemented to promote learners' critical thinking.

Aim of the study

The aim of the study was thus to investigate the effects of case study teaching on learners' critical thinking skills in Physical Sciences classrooms at secondary school level.

Hypothesis

Case study teaching develops learners' critical thinking skills in Physical Sciences classrooms at secondary school level.

THEORETICAL FRAMEWORK

The study operated under the assumptions of the network theory of learning, Vygotsky's social constructivist theory of learning and Habermas' theory of communicative action. Firstly, the network theory of learning accentuates the use of learners' contexts in the teaching of Physical Sciences so that learners can relate what they are learning in class to their real- life experiences (Shunk, 1996). In addition, social constructivists believe that learner-to-learner interaction is central to effective learning (Vygotsky, 1969). Furthermore, constructivists believe that the social context is significant for effective learning and that children should build their own knowledge (Zhou & Brown, 2015). Critical thinking is also closely related to long-term memory that is built through a process called comprehension (Pollock, Chandler, & Sweller, 2002). According to Pollock, Chandler and Sweller (2002), comprehension is a process of transferring information from short-term to long term memory which occurs after the activation of the schemata (existing knowledge) (Norris & Phillip, 1987). It can be argued that in a learning environment where case study teaching is employed the process of comprehension is accelerated as familiar stories assist in linking the learners' schemata to the new information according to the network theory. Acceleration of the comprehension process will in turn assist in enhancing learners' critical thinking skills. In addition, effective learning will occur when learners are given challenging open-ended questions (Topolovcan & Matijevic, 2017). Teaching critical thinking, from a philosophical paradigm focuses on teaching learners to identify and evaluate the claim (Faize, Husain, & Nisar, 2018).

The theory of communicative action can also be applied in the teaching of critical thinking skills in any classroom (Tuzlukova, Al Busaidi, & Burns, 2017). According to Habermas (1984), the main concepts that define communicative action are dialogical knowledge and communicative rationality in which learners are free to exercise their freedom of speech and to negotiate meaning towards collective views or agree to disagree on some points (Habermas, 1984). With Habermas' communicative action in mind, this study emphasised the significance of the development of democratic values among learners so that they could employ them during group and class discussions.

LITERATURE REVIEW

Critical Thinking Skills

Critical thinking skills is defined by Wood (2002) as the ability to apply logic (inductive or inductive reasoning) to separate the truth from fiction. In the context of this study, critical thinking skills are defined as skills that enable one to solve unseen problems where algorithms or procedures that can lead to the solution are not defined or known (Beckisheva, Gasparyan and Kovalenko, 2015; Herreid, 1994). There is a general agreement that critical thinking skills can be taught and assessed (Gul, Khan, Ahmed, Cassum, Saeed, & Parpio, 2014; Jeronen, Palmberg, & Yli-Panula, 2016). Marin and Halpern (2011) further postulate that the teaching of critical thinking skills at secondary school level can be performed without adjusting the school curriculum. Important critical thinking skills that are expected to be taught to Physical Sciences learners at the secondary school level include reasoning, hypothesis testing, argument evaluation, data analysis, problem solving and decision-making skills (DoBE, 2011; Tiruneh, De Cock, Weldeslassie, Elen, & Janssen, 2017).

A pedagogy that can be successful in the teaching of critical thinking skills in Physical Sciences classrooms should encourage learners to read, write and talk like scientists and encourage maximum interaction among learners through group and class discussions (Wang & Seepho, 2017; Weinstein & Priess, 2017). Classroom discussions are very important in developing learners' critical thinking skills as they maximise learner participation, improve learners' communication skills and magnify their understanding of the contents under discussion (Zivkovic, 2016). Moreover, Dagar and Yadav (2016) argued that a pedagogy that would be successful in developing leaners' critical thinking skills is one that would bring the social and emotional aspects of their lives into science classrooms. The emotional and social aspects can be brought into the clssrooms through contex-based teaching pedagogy that prioritise learner-to-learner interactions (Podschuweit & Bernholt, 2017). Stories used in case study teaching can bring the social and emotional aspects into the classroom learning environment. In addition, Weinstein and Priess (2017) argue that one of effective ways of enhancing learners' critical thinking skills is to give them sories that they would enjoy.

Teaching CTS aims to teach children to think like scientists (Schmaltz, Jansen, & Wenckowski, 2017; Heid, Biglan, & Ritson, 2008). Activities that enhance CTS in the classroom are called learning by thinking (Luntley, 2008). Elements of critical thinking include critical reasoning (learners' ability to weigh reasons); critical attitude and moral orientation which motivates critical thinking and knowledge of a particular subject" (Mason, 2008, p. 5). Fundamental to the development of critical thinking skills is affording learners an opportunity to construct arguments with justifications. This process enables learners to feel empowered as it provides them with an opportunity to make their own judgements (Luntley, 2008).

One of the most important components of critical thinking is critical reading which involves an analysis of the text and the identification of the claim made by the author and evidence that supports the claim including the weaknesses of the claim (Oliveras, Márquez, & Sanmartí, 2013). Learners with adequate critical thinking skills question the applicability of every claim that is made in the text that they read which encourages them to read even more widely to gather evidence in support of their claims. According to the Welsh Assembly Government (2010) and Topolovcan and Matijevic (2017), critical thinking skills lead to a better understanding of the learnt content and better performance in tests and examination

Critical thinking is closely related to long-term memory that is built through a process called comprehension (Pollock, Chandler, & Sweller, 2002). According to Pollock, Chandler and Sweller (2002), comprehension is a process of transferring information from short-term to long term memory which occurs after the activation of the schemata (existing knowledge) (Norris & Phillip, 1987). It can be argued that in a learning environment where case study teaching is employed the process of comprehension is accelerated as familiar stories assist in linking the learners' schemata with the new information according to the network theory. Acceleration of the comprehension process will in turn assist in enhancing learners' critical thinking skills. According to Topolovcan and Matijevic (2017), critical thinking plays a central role in the learning process from the perspective of the constructivist paradigm, which views learning as an active process aimed at assisting learners to make sense of their world. In addition, effective learning will occur when learners are given challenging open-ended questions (Topolovcan & Matijevic, 2017). Teaching critical thinking, from a philosophical paradigm, is to teach learners to identify and evaluate the claim (Kapian, 1991; Faize, Husain, & Nisar, 2018). Classroom activities that induce mental disequilibrium and foster metacognition processes in learners are handy in limiting learners' misconceptions (Jiang, Wang, Wang, & Ma, 2018). The theory of communicative action is one of the strategies recommended for the teaching of critical thinking skills in any classroom (de Souza, Carvalho, Vitor, Cogo, Santos, & Ferreira, 2017). The communicative action approach could be implemented to develop learners' critical thinking (Tuzlukova, Al Busaidi, & Burns, 2017). Communication is defined as "a tool for achieving extra-linguistic goals that satisfy extra linguistic needs and interests" (Tuomela, 2002, p. 30). According to Habermas (1984), the main concepts that define communicative action are dialogical knowledge and communicative rationality in which learners are free to exercise their freedom of speech and to negotiate meaning towards collective views or agree to disagree on some points (Habermas, 1984). With Habermas' (1984) communicative action in mind, this study emphasised the significance of the development of democratic values among learners so that they could employ them during group and class discussions. The fact that learners need to support their viewpoints with reasons was also emphasised before the commencement of case study teaching.

Case Study Teaching

A case study can be defined as an anecdote with a message that can be used to teach subject contents under any learning environment (Herreid, 1997). Hence, within the context of this study, case study teaching is defined as a pedagogy that encompasses providing learners with a story related to the topic that is learned, and asking them questions based on the story (Beckisheva, Gasparyan and Kovalenko, 2015; Herreid, 1994). According to Herreid (1997, p. 92), case study teaching is advantageous as learners in the class room are human beings and "human beings are story loving animals".

Case study teaching can encourage learners to read, write and talk like scientists while learning Physical Sciences (subject) content (Bonney, 2015); as a result, the critical thinking of the learners will develop simultaneously with Physical Sciences knowledge (Dowd, Thompson, Schiff, & Reynolds, 2018). Argumentative talks, during case study teaching, are the basis for the development of critical thinking skills (Webb, Whitlow, & Venter, 2017). The implementation of case study teaching in Physical Sciences classrooms can be a means to bridge the gap between what learners learn in the classoom and what is happening in real life (Minniti, Melo Jr, Oliveira and Salles, 2017). Case study teaching can be an important Physical Sciences teaching pedagogy at secondary school level as it can improve learners'attitudes towards Physical Sciences to become favourable (LaForce, Noble, & Blackwell, 2017). However, research still needs to provide empirical evidence on which methods are effective in teaching learners to think, read and write like scientists and to separate the truth from fiction in Physical Sciences classrooms at secondary school level (Schmaltz, Jansen, & Wenckowski, 2017). On the other hand, case study was found to be an effective pedagogy for incorporating the teaching of critical thinking skills at the post-secondary school level. This study investigated the effects of case study teaching on learners' critical thinking skills in physical sciences at secondary school level. According to Herreid (1994), case studies can take various formats, which include discussion, in which problem questions are posed, learners adopt views and their views are debated; the public hearing (trial) format in which learners form a panel that will role-play the normal court process; scientific research format which follows steps in the scientific process; and the common problem-based format in which learners solve some problems. This study adopted a problem-based case study teaching approach in which learners are given a science topic related story with question and learners are allowed to respond to the questions as individuals, after that they discuss their answers in their groups and share their collective group answers with the whole class. This approach to case study teaching can be effective as it embeds elements of constructivist learning, communicative action and context-based learning (where Physical Sciences related stories are used as contexts) into the teaching and learning of science knowledge.

This study employed a case study teaching strategy that encompasses elements of more than one case study teaching strategy. The study was concerned mainly with three aspects in implementing a suitable approach for applying case study teaching in the Physical Sciences classrooms. Firstly, the study intended to use case studies to introduce the lesson so that Physical Sciences lessons could be introduced by motivating learners to read about science. Secondly, the study aimed to afford individual learners adequate time to read case studies, respond to case study questions and share their views in their groups and with the class. Lastly, this study intended to use case studies to provide learners with a context to which they could apply the scientific knowledge they learnt in their Physical Sciences classrooms. This study did not follow any pre-existing model of case study teaching hence at the end of this study, a model that could be suitable for incorporating the teaching of critical thinking and language literacy skills is proposed.

RESEARCH METHODOLOGY

This quantitative study adopted a non-equivalent (pre-test and post-tests) control-group quasi-experimental design. Experimental design was chosen because this study evaluated the effectiveness of a teaching method. The quasi-experimental design was adopted because random assignment and control over the experimental environment were impossible (Brink, van der Walt, & van Rensburg, 2012).

The population for the purposes of this study were all Grade 10 learners studying Physical Sciences (through their second language – English) in the secondary schools of Sekhukhune East (Formerly Riba Cross) District in the Limpopo Province of South Africa. Sekhukhune East District was chosen because of the general poor performance as learners from the district performed at position

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75 out of 75 districts in the country (South Africa) with only 63 % of 6707 learners who sat for National Senior Certification (NSC) examinations in 2019 managing to obtain the minimum requirements for the certificate (Department of Basic Education, 2020). Four schools (two rural and the other two urban) were identified for the purposes of the study and from these schools 122 learners constituted the sample which were distributed as follows:

Table 1: Number of participants per group

		Frequency	*Percent*
Valid	*Experimental Group Urban*	30	24,6%
	Experimental Group Rural	29	23,8%
	Control Group Rural	41	33,6%
	Control Group Urban	22	18,0%
Total		122	100,0%

One rural school was treated as the experimental group while the other one as a control group. The same applied to the urban schools. It is also worth noting that the rural control group is bigger than the urban control group. Reason for the difference is that it was very difficult for the researcher to find urban schools that were suitable to take part in this study as most of them registered small (fewer than 15) number of learners studying Physical Sciences in Grade 10. Urban schools have introduced Technical Sciences which enrol learners who want to do science related courses post-secondary school but fear Physical Sciences, whereas rural schools are yet to introduce Technical Sciences which gives rural learners no option but do Physical Sciences if they are to study science related courses post-secondary. In terms of gender, the number of males was slightly bigger than that of their female counterparts as the following table indicates:

Table 2: Number of learners in terms of gender

Gender					
		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	*Male*	64	52,5%	52,5%	52,5%
	Female	58	47,5%	47,5%	100,0%
Total		122	100,0%		

64 (52,5 %) males and 58 (47,5 %) females participated in the study.

Data were collected through the adapted Critical Thinking in Electricity and Magnetism test (CTEM). The CTEM test is a content specific critical thinking test originally designed by Tiruneh, De Cock, Weldeslassie, Elen and Janssen (2016). The original test consisted of 20 items and was found to be reliable, with the Cronbach's alpha value of 0,72 and Cohen's kappa value of 0,83 which showed some degrees of reliability, when tested with Belgian secondary school learners. For this study, the instrument was adapted for Grade 10 learners (as prescribed in the CAPS document) and as a result, the number of items in the instrument were reduced to eight (8). Critical thinking skills measured by the CTEM test include reasoning, hypothesis testing, argument evaluation, data analysis, problem solving and decision-making skills (Tiruneh, De Cock, Weldeslassie, Elen and Janssen, 2016). The adapted test was given to four Physics teachers and a subject advisor to assess in terms of whether the items in the test were relevant for Grade10 learners and whether the test measured what it intended to measure, and the necessary adjustments were effected to the test. For internal consistency reliability of the CTEM test, the test was administered to Grade 10 learners from the school in the district, but who were not part of the sample identified for the purposes of the study. The test scripts were marked, and the results were analysed through PSPP package. The following table (Table 3) shows the results of the reliability test:

Table 3: Cronbach's alpha value for the CTEM test

Cronbach's Alpha	*N of Items*
0,80	8

Table 3 (above) indicates that the Cronbach's alpha value for the CTEM test was 0,80 which is greater than 0.7, which indicates that the tool is reliable.

Data Collection

The control groups (CGs) were taught in the traditional ways of teaching Physical Science while the experimental groups were taught using case study teaching. Both experimental and control groups were taught by the researcher using English as the language of teaching and learning (LoLT). Five case studies were included in the teaching of the Experimental Group (EG). Both EGs and CG were taught Electricity and Magnetism which forms part of the work that was to be taught to Grade 10. Data Collection lasted for a period of 9 weeks. Participants, in both EGs and CGs, were given the CTEM test at the beginning of the study as a pre-test, followed by interventions and concluded by giving participants the CTEM test as the post-test.

Analysis of data

Test scripts were marked, and the results were analysed quantitatively using both descriptive (means and percentage) and inferential (parametric t-test, non-parametric Mann-Whitney U test and Cohen's d value) approaches. The statistical values were computed through PSPP statistical package (available freely online).

Findings

General findings: The Effects of Case Study Teaching on Critical Thinking Skills

The following table (Table 5) indicates that the mean of the combined experimental groups (M = 4,75), in the pre-test, is bigger than that of the combined control groups (M = 3,25).

Table 4: CTEM test mean scores for combined groups

	Group	*N*	*Mean*	*Std. Deviation*	*S.E. Mean*
CTEM Pre-test	*Experimental group*	59	4,75	2,38	0,31
	Control Group	63	3,25	2,88	0,36
CTEM Post-test	*Experimental group*	59	8,56	3,55	0,46
	Control Group	63	4,60	3,77	0,48

A two-tailed t-test was conducted on the results of the pre-test and it was discovered that the differences in means between the combined experimental and control groups was statistically significant as the p-value (p = 0,002) is less than the significant value of 0,05. This means that a comparison of the post-test means will not make any statistical sense as the combined experimental groups were significantly better than the combined control groups in terms of the critical thinking skills. In cases like this, the reliable comparison yardstick is the gain score (the difference of the post-test and pre-test scores). The mean and median gain scores were compared through two-tailed t-test and Mann-Whitney U test. The following table (Table 5) shows the respective means:

Table 5: Mean gain scores of CTEM for the combined groups

	Group	*N*	*Mean*	*Std. Deviation*	*S.E. Mean*
CTEM Gain Score	*Experimental group*	59	3,81	3,46	0,45
	Control Group	63	1,35	3,47	0,44

The mean gain score (3,81) for the combined EGs is bigger than the mean gain score (1,35) for the combined CGs. The mean of 3,81 out of 30 is 12,7 % for the combined EGs and the combined CGs gained by 4,5 %. The difference in gain scores is 8,2 %, which means that the combined EGs, which were taught through CST, have generally gained by 8,2 % more than their counterparts

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in the combined CGs, who were taught through the traditional way of teaching Physical Sciences. In addition, a two-tailed t-test was conducted to test whether the difference in the means was statistically significant. The p-value (p = 0,000), for the t-test, is less than 0.05, which means the difference in mean gain score is statistically significant. The results were confirmed by conducting the Mann Whitney U test and Table 6, below, indicates the results of the Mann Whitney U test.

Table 6: Mann Whitney U test for CTEM gain score for combined groups (mean ranks)

		N	*Mean Rank*	*Sum of Ranks*
CTEM Gain Score	*Experimental group*	59	77,55	4575,50
	Control Group	63	46,47	2927,50
	Total	122		

Table 7: Mann Whitney U test for CTEM gain score for combined groups (test statistics)

	Mann-Whitney U	*Wilcoxon W*	*Z*	*Asymp. Sig. (2-tailed)*
CTEM Gain Score	911,50	2927,50	-4,88	0,000

The mean rank for the combined experimental groups (77,55) is bigger than the mean rank of the combined control groups (46,47) which is statistically significant as the p-value (p = 0,00) for the Mann Whitney U test is less than the significant value of 0,05. T-test and Mann Whitney U test results indicate that learners in the experimental group gained more, in terms of critical thinking skills, than their counterparts in control groups. This, therefore, means that CST has an effect on learners' critical thinking skills and the effect size was calculated as follows:

$$Effect\ size\ (d) = \frac{(Mean\ of\ Experimental\ group) - (Mean\ of\ control\ group)}{standard\ deviation}$$

$$= \frac{3{,}81 - 1{,}35}{3{,}65} = 0{,}67$$

The effect size (d = 0,67) is medium to large, which means that CST has a statistically medium effect on learners' critical thinking skills.

Effects of Case Study Teaching According to the Geographical Location

Table 8, below, indicates the comparison of the gain score from the two groups:

Table 8: Mean gain scores of CTEM tests for urban groups

	Group	*N*	*Mean*	*Std. Deviation*	*S.E. Mean*
CTEM Gain Score	*Experimental Group Urban*	30	3,20	2,70	0,49
	Control Group Urban	22	0,05	1,40	0,30

The EG (urban) has gained more, in terms of critical thinking skills, than the CG. The mean gain score of the EG is 3,20 out of 30 (10,7 %) whereas the one for the CG is only 0,05 out of 30 (0,05 %). Mann Whitney U test results, Table 9 and Table 10, below, indicate that the difference in gain scores is statistically significant.

Table 9: Mann Whitney U test results of CTEM test gain scores for urban groups (mean ranks)

		N	*Mean Rank*	*Sum of Ranks*
CTEM Gain Score	*Experimental Group Urban*	30	34,75	1042,50
	Control Group Urban	22	15,25	335,50
	Total	52		

Table 10: Mann Whitney U test results of CTEM test gain scores for urban groups (test statistics)

	Mann-Whitney U	*Wilcoxon W*	*Z*	*Asymp. Sig. (2-tailed)*
CTEM Gain Score	82,50	335,50	-4,63	0,000

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The mean rank of the urban EG (34,75) is significantly greater than that of the urban CG (15,25) as the p-value (p = 0,00) is less than the significant value of 0,05. From the Mann Whitney U test results, it can be concluded that learners in the EG in the urban area gained more than their counterparts in the CG in terms of the critical thinking skills. This means that CST also has an effect on the critical thinking skills of the learners from the urban area. The effect size of the data is 1,79, which is very big.

For the rural groups, the means were compared and Table 11 and Table 12, below, shows the results obtained:

Table 11: Mann Whitney U test results of CTEM for rural groups (mean ranks)

		N	*Mean Rank*	*Sum of Ranks*
CTEM Post-test	*Experimental Group Rural*	29	43,36	1257,50
	Control Group Rural	41	29,94	1227,50
	Total	70		

Table 12: Mann Whitney U test results of CTEM for rural groups (test statistics)

	Mann-Whitney U	*Wilcoxon W*	*Z*	*Asymp. Sig. (2-tailed)*
CTEM Post-test	366,50	1227,50	-2,73	0,006

The mean rank of the rural EG (43,36) is bigger than the mean rank of rural CG (29,94) in a statistically significant manner as the p-value (p = 0,006) for the Mann Whitney U test is less than the significant value of 0,05. An inference that can be formulated from the Mann Whitney U test results is that case study teaching (CST) has an effect on critical thinking skills of the learners from the rural area. The effect size for this comparison is 0,58 which is also between medium and small. It is also worth noting that effect size value for rural group (d = 0,58) is smaller than the one for the urban group of 1,79: that is more than three-fold. This means case study teaching improved the critical thinking skills of the urban group three times more than their counterparts from the rural areas.

Effects of Case Study Teaching According to Gender

The performance of the learners in CTEM tests was also analysed according to participants' gender. The table (Table 15) below displays group means according to gender.

Table 13: CTEM means in terms of gender

	Group	*N*	*Mean*	*Std. Deviation*	*S.E. Mean*
CTEM Pre-test	*Male*	64	4,13	2,86	0,36
	Female	58	3,81	2,63	0,35
CTEM Post-test	*Male*	64	6,47	3,94	0,49
	Female	58	6,57	4,43	0,58
CTEM Gain Score	*Male*	64	2,34	3,53	0,44
	Female	58	2,76	3,82	0,50

The means of the combined experimental groups in the pre-test, post-tests and gain scores are slightly different and the p-values from a two-tailed t-test comparing the combined experimental groups are all greater than the significant value of 0,05. Levene's test results for CTEM pre-test, CTEM post-test and CTEM gain score indicate that the variances of the two gender groups are equal as their p-values (0,089, 0,833 and 0,933 respectively) are greater than the critical value of 0,05. The p-values for the post-test and gain score are greater than the significant value of 0,05. This means that CST improved the performance of female learners as much as that of their male counterparts.

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DISCUSSION

The main aim of this study was to test the following hypothesis (alternative): *Case study teaching develops learners' critical thinking skills in Physical Sciences classroom at secondary school*. The null hypothesis that goes with the stated alternative hypothesis is that case study teaching has no effect on learners' critical thinking skills in Physical Sciences classrooms. The findings of the study support the rejection of the null hypothesis and acceptance of the alternative hypothesis as the general results of the study found that case study teaching improves learners' critical thinking skills in Physical Sciences classrooms. Case study teaching worked because it involved learners in what Habermas (1984) termed communicative action because during the intervention in the EGs (where case study teaching was employed), learners were free to exercise their freedom of speech and to negotiate meaning towards collective views or agree to disagree on some points. The results of the study confirm Tuzlukova, Al Busaidi and Burns' (2017) assertion that a pedagogical strategy that involves learners in communicative action is a useful tool for enhancing their critical thinking skills. We argue that case study teaching improved learners' critical thinking skills because it complies with all the requirements of constructivist teaching theory and integrated the social and emotional aspects of learning through stories and discussions (Dagar & Yadav, 2016; Topolovcan & Matijevic, 2017). Case study teaching improved learners' critical thinking because it involved them in a practice that integrate theory (Physical Sciences content), action (group discussion and presentations) and reflection (teacher guided classroom discussions) as this promotes democratic values in the classroom and make learners feel that their opinions contribute towards their learning (Wang & Seepho, 2017; Weinstein & Priess, 2017).

Learners' critical thinking skills improved because while learners were talking and sharing ideas with their classmates, they were involved in argumentation. This resonates with Faize, Husain and Nisar's (2018) viewpoints that a pedagogical strategy that encourages learners to read and argue from evidence is more likely to improve their critical thinking skills. This also reaffirms the views of Dowd, Thompson, Schiff and Reynolds (2018) who argued that the most important approach to develop critical thinking skills is to afford learners an opportunity to construct their own arguments with justifications. This process enables learners to feel empowered, as it affords them with an opportunity to make their own judgements and to draw conclusions from cases studied based on evidence derived from the cases. In addition, Webb, Whitlow and Venter (2017) postulated that argumentation improves scientific reasoning skills which was the case in the study. Permitting learners to work in groups seem to be one of the most important features of a pedagogy that aims at improving learners' critical thinking skills (Jeronen, Palmberg, & Yli-Panula, 2016).

The results also indicate that critical thinking among urban learners indicated a better improvement than that of their counterparts from rural schools. A reason for that may be that case study teaching encourages learners to learn even outside the classroom and rural learners have limited resources in terms of libraries, the internet and newspapers that can assist them in this regard. This means that the implementation of case study teaching in rural schools would yield better results if learners are equipped with resources that will enable them to search and find information that is related to their studies on their own. Finally, critical thinking skills of female learners improved as much as that of their male counterparts which, once more, signifies that case study teaching could be implemented effectively as pedagogy for gender redress. We argue that case study teaching can narrow the achievement gap, between male and female learners in Physical Sciences.

The teaching of critical thinking skills is highlighted in various theories. For example, Topolovcan and Matijevic (2017) are of the view that constructivist teaching improves critical thinking skills. This means that if critical thinking skills are to be improved, science teachers should integrate the social and emotional aspects of learning through the constructivist theory of learning (Dagar & Yadav, 2016). In addition, any teaching that is intended to improve critical thinking skills should be completely learner-centred (Puspita, Kaniawati, & Suwarma, 2017). Furthermore, the teaching of critical thinking skills cannot be done in isolation but should be incorporated into the teaching of subject content. Teaching through a methodology that is inquiry-based, with the focus on context, has all the characteristics described above. Inquiry-based teaching can enhance the learners' ability to use evidence to support or refute a claim. On the other hand, contextualised teaching and learning leads to improved conceptual understanding, irrespective of which form it takes (Podschuweit & Bernholt, 2017). Contextualised learning can be a better bridge between the knowledge that exists in learners' cognitive structure and the new information learners are expected to learn. Hence the choice of contexts/scenarios/stories is crucial for effective teaching and learning to be realised. It can be argued that case study teaching is a contextualised pedagogical strategy as it employs the use of real life stories as the context to link learners' existing knowledge with the new information and a context to which the new knowledge could be applied. Case study teaching can also succeed in enhancing learners' critical thinking and language literacy skills because it reinforces important practices postulated for contextualised pedagogy.

A number of studies highlight the value of constructivist teaching methodologies as ways of improving learners' critical thinking skills. For instance, group discussions, concept mapping and analytic questioning were found to contribute towards university English language learners' effective promotion of critical thinking skills (Wang & Seepho, 2017). These methods are effective because group discussions encourage learners to share their views, which lead to shared understanding. On the other hand, concept mapping enables the learners to gain a visual perspective of the problem while analytic questioning prompts learners to apply their logical (inductive and deductive) thinking skills to the text (Wang & Seepho, 2017).

CONCLUSION

This study investigated the effects of case study teaching on learners' critical thinking skills and found that case study teaching improves learners' critical thinking skills. The study further found that the critical thinking skills of urban learners improved three times more than that of their rural learners when both received case study teaching instructions. Furthermore, the study found that case study teaching improves critical thinking of female learners as much as that of their male counterparts. The results of this study form an important foundation in the teaching of critical thinking skills in Physical Sciences classrooms at the secondary school level through the use of case study teaching. However, more studies need to be conducted with larger samples, over a prolonged period with a focus on different Physical Sciences topics.

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