Sciences teachers' creation of constructivist learning environments in their classrooms

Sezanele Gugulethu Mbonane [a], University of Johannesburg, Cnr Kingsway Ave and University Rd, Auckland Park, Johannesburg 2006, South Africa

Lydia Mavuru [b*], University of Johannesburg, Cnr Kingsway Ave and University Rd, Auckland Park, Johannesburg 2006, South Africa

Abstract

The study sought to establish science teachers' perceptions about the learning environments and how they implemented constructivist teaching strategies. An explanatory mixed method research design was adopted. The Constructivist Learning Environment Survey was administered to 180 purposively selected grade 10-12 science teachers from 30 schools and analysed using descriptive statistics. Semi-structured interviews were administered to five selected teachers who had shown to be more constructivist than others and data was analysed using constant comparative method. Social constructivism was adopted as the theoretical framework. Findings revealed teachers' positive disposition in relation to personal relevance, learner negotiation and critical voice as some of the key constructs depicting a constructivist learning environment. Teachers' disposition in relation to shared control and scientific uncertainty reflected traditional perceptions. Teachers used cooperative teaching strategies, real-life examples, and questions to elicit learners' prior knowledge. Findings have implications for teacher professional development in classrooms showing diversity in learners' backgrounds.

Keywords: Constructivist learning; learner-centred classrooms; prior knowledge; social constructivism

---

[*] ADDRESS OF CORRESPONDENCE: Lydia Mavuru, University of Johannesburg, Cnr Kingsway Ave and University Rd, Auckland Park, Johannesburg 2006, South Africa
Email address: lydiam@uj.ac.za

1. Introduction

One assumption underlying traditional models of teaching and learning is that science knowledge is absolute, without nuance of meaning; and this is at variance with modern notions of science and the contemporary thrust on learning for understanding. Whilst previous research has attributed the use of teacher-centred approaches to lack of resources to promote learner-centred approaches (Mavuru & Dudu, 2021; Ramnarain, 2021), the argument herewith is that when a constructivist learning environment is created, even with limited resources, teachers should be able to help learners understand scientific concepts. Like the science curricula in most countries, the South African science curriculum is based on principles of learner-centred instruction as an active and critical approach to learning as opposed to rote and uncritical learning (Department of Basic Education, 2011). Learners need to be equipped with knowledge and skills to identify and solve problems and make decisions using critical and creative thinking; work both as an individual and as a team member; and critically use science and technology to solve problems, which Loyens and Gijbels (2006) view as central to constructivist principles. Teaching should be a process where learners are at liberty to think critically, discover concepts, facts, and reality among themselves (Omodan & Tsotetsi, 2020).

Problem statement

There has been consistency in poor performance of learners in science, technology, engineering, and mathematics (STEM) subjects in South Africa (Grayson, 2010) and other developing countries. Factors that could be disadvantaging learners are attributed to but not limited to language of teaching and learning which is different from learners' home languages, socio-economic background, and curriculum (Mavuru & Ramnarain, 2017; Phakeng & Moschkovich, 2013). However, unfavourable learning environments have been found to bedevil the meaningful teaching and learning of the science subjects (Reddy et al. (2015), which ill prepares learners for meaningful science learning. du Plessis and Mestry (2019) posit that the teaching environment determines the learning process and learner performance. The current study is predicated on the concerns raised by Booyse and Chetty (2016) that there are retrogressive practices which are bent on side-lining constructivist efforts in the classrooms. This is in light of the changing teaching and learning platforms, which are now more inclined towards online/remote due to COVID-19 pandemic.

2. Theoretical framework

2.1 constructivism

The study is underpinned by constructivism as the theoretical framework. Constructivism is defined as a learning approach which accords learners the opportunity to construct, interpret and reorganise their knowledge (Windschitl, 2010); a theory of "knowing" the nature of knowledge (Phillips, 2000); which Martin (2006) described as consonant with the notion of subjective reality. Earlier Jonassen (1999) envisaged constructivist environments as encouraging learners to discover, discuss and interpret knowledge by assisting learners to construct and implement their own theories as a way of reflecting on gained knowledge and skills. Constructivist learning environments support learners in taking responsibility for their own construction of knowledge, which Marlowe and Page (2005) viewed as only possible if processes like questioning, problem-solving and researching in classroom settings is done rigorously. A constructivist learning environment defines the role of the teacher and learners as not competing but rather complementing each other in a nurturing way (Benudhar & Moumita, 2013).

2.2 Learning environments in science classrooms

Constructivist teaching and learning demands effort from both the teachers and learners (Hajal, 2019). To create constructivist learning environment in a science classroom, the teacher's attitude should be positive towards constructivism as a means through which meaningful learning occurs. In a study to investigate Lebanese teachers' perceptions of the constructivist theory when applied in the classroom, Hajal (2019) found that the teachers' perceptions were more aligned with traditional teaching approaches, and based on lesson observations, their teaching was not constructivist oriented. The teachers were found lacking in knowledge of constructivist theory application in the classroom particularly on the different constructivist teaching methods (Hajal, 2019). The constructivist learning environment is formed by the instructions of what the teacher says or does (Unal & Akpinar, 2006).

Teachers' perceptions have also been found to be important in determining how teachers create constructivist learning environments in their classrooms and in some studies, it has been found that there is a mismatch between teachers' perspectives and practices. For instance, when investigating Ethiopian teachers' perceptions and practices of constructivist teaching approach in secondary schools, Melesse and Jirata (2015) found that all the teachers were positive with regards to the need to implement constructivist approach. However, from the lessons observed, all the teachers did not utilise the different teaching strategies that portray a constructivist approach (Melesse & Jirata, 2015). When interviewed, the teachers indicated that implementing constructivist teaching approach is difficult due to their lack of skills, large class sizes, and inadequate resources. The issue of teachers' lack of skills was also echoed by Taskin-Can (2011) that if teachers are not well prepared or developed to implement constructivist teaching approach, it is difficult for them to create constructivist learning environments in their classrooms.

Technological gadgets have also been regarded as a panacea in activating prior knowledge in classroom learning environments (Kaya, 2015). In concurrence previous studies found that constructivist teachers tend to utilise technology in their classrooms (Ertmer, 2005; Mutlu, 2011). In a study to determine the conveniences of using technology in a constructivist classroom, Isik (2018) confirmed that technology supports constructivist learning environments by activating learners' prior knowledge, enhancing learners' abilities to accommodate differences (diversity), and supporting communication and collaboration in the classrooms. This is consistent with Vygotsky's (1978) proposition that learning takes place in a social setting, which was also authenticated by other researchers. In concurrence, Honebein (1996) proposed that a constructivist classroom should implement collaborative strategies. The benefit is that learners learn more and enjoy more when they are actively involved (Bada, 2015).

Based on the arguments given above, teachers' perceptions are key when it comes to implementation of constructivist learning environments. Consequently, the current study addressed the following objectives: 1. To investigate how teachers perceive learning environments in their science classrooms with respect to constructivism. 2. To explore how science teachers implement constructivist teaching strategies in their classrooms.

3. Methods

In this study we followed an explanatory sequential mixed method research design (Creswell, 2014). Quantitative data was collected and analysed, and the results used to design the collection of qualitative data (Creswell, 2017).

3.1 Selection of participants

A purposive sampling technique was employed to select 180 grade 10, 11 and 12 science teachers from 15 public schools in Johannesburg. A minimum of three years teaching experience was the criterion as teachers were considered to have familiarised themselves with the dictates of both the curriculum and the nature of science classroom environments. The study satisfied the ethical requirements of the institutions involved and permission from all participants was obtained.

3.2 Data collection

A 5-point Likert scale Constructivist Learning Environment Survey (CLES) originally developed by Taylor and Fraser (1991) and revised by Johnson and McClure (2004), was administered to 180 teachers to establish whether the learning environments in their classrooms adhered to constructivist approaches. The instrument has been validated in studies conducted in many countries including Korea, United States, Taiwan, and Australia (Aldridge, et al., 2004). It has five scales relevant to the constructivist principles, namely, personal relevance; uncertainty; critical voice; shared control and learner negotiation (Taylor et al., 1997). The respondents indicated their extent of agreement on a five-point Likert scale: strongly agree, agree, neutral, disagree, and strongly disagree which were assigned values of 5, 4, 3, 2, and 1 respectively. This helped in quantifying the results. The reliability data obtained suggest that the CLES instrument has acceptable internal consistency of Cronbach's Alpha above 0.7 for the 20 items.

From the analysis of quantitative data, five teachers: King, Lungi, Hlayi, Calvin and Flo (pseudonyms), were purposively selected for collection of qualitative data through interviews because they showed to be more constructivist than others. Each teacher was interviewed once through face-to-face semi-structured interviews to explore their knowledge about the characteristics of a constructivist learning environment; and how their perceptions inform the teaching strategies they employ in their science classrooms. Semi-structured interviews allowed flexibility (Fylan, 2005) as researchers probed for more information (Taylor & Bogdan, 1998).

3.3 Data Analysis

A deductive approach was used to analyse both the quantitative and qualitative data. Quantitative data from the CLES questionnaire was analysed using Statistical Package for Social Sciences (SPSS) version 26 to obtain descriptive statistics which helped researchers to describe, summarise, explain, and make sense of the quantitative data (Johnson & Christensen, 2014). Qualitative data from interviews were analysed using constant comparative method (Merriam, 2000), where the researchers sought codes that recurred from each teacher's responses; categorised common codes (Saldana, 2009) and then identified emerging patterns (Bloomberg & Volpe, 2012). Constant comparative method was suitable because it started with raw information and with steady examination, meaning was then constructed (Leech & Onwuegbuzie, 2007).

4. Results

4.1 Teachers' perceptions of learning environments in their science classrooms

Analysis of quantitative data showed a positive disposition with regards to personal relevance (93%), critical voice (89%) and learner negotiation (74%) as some of the key constructs depicting a constructivist learning environment. Teachers showed negative perceptions in relation to scientific uncertainty (67%) and shared control (45%), which revealed their orientation towards traditional teaching approaches. The following is a presentation of the findings under each construct.

4.1.1 Personal relevance

Personal relevance measures whether learners' personal experiences and background are considered as part of instructional strategies in the classroom. Table 1 shows the teachers' perceptions regarding the personal relevance construct.

Table 1. Summary of how teachers perceived personal relevance

Item	Distribution of responses (%)		
	Strongly agree/ Agree	Neutral	Disagree/ Strongly disagree
Learners learn about the world.	94	4	2
New learning relates to experiences or questions about the world inside and outside of school.	100	0	0
Learners learn how learning new things is part of lives inside-and-outside-of-school lives.	90	4	6
Learners learn interesting things about the world.	88	10	2
Average	93	4	3

On average all the teachers obtained a score of between 4.5 and 5, for each item, indicating that they had constructivist views. Their responses showed that they related classroom activities with what learners experienced outside school, which is one of the principles of a constructivist classroom. Personal relevance is now more important than ever considering that due to online/remote teaching taking centre stage in the wake of COVID-19 pandemic, learners become motivated to learn new knowledge and skills they perceive as relevant in their personal lives.

4.1.2 Scientific uncertainty

The construct scientific uncertainty measures the extent to which learners are given opportunities to experience science knowledge as involving human experience and values; and that science is culturally and socially determined (Taylor et al., 1997). Table 4 shows how teachers perceived the scientific uncertainty construct.

Table 2. Summary of how teachers perceived scientific uncertainty

Item	Distribution of responses (%)		
	Strongly agree/ Agree	Neutral	Disagree/ Strongly Disagree
Learners learn that there are not always answers to problems.	50	16	34
Learners learn that explanations to things have changed over time.	68	20	12
Learners learn that ideas are influenced by people's cultural values and opinions.	82	14	4
Average	67	17	17

In item 1, 34% who disagreed raised concerns because it meant that these teachers depended on textbooks for answers. They were not accommodative of learners' opinions. In item 2, a total of 32% of the teachers indicated that they were neutral or disagreed that scientific explanations changed over time yet in a constructivist classroom, learners should be exposed to scientific uncertainty to develop critical thinking skills. In a way these teachers do not expose learners to the nature of science. Most of the teachers (82%) were aware that socio-cultural practices have an impact on learning, which shows that they considered learners' prior knowledge when teaching.

4.1.3 Critical voice

The construct provision of critical voice in the science classroom measures the extent to which learners feel free to question the teacher's pedagogical plans and methods. Many of the teachers expressed positive perceptions, meaning that their learners were comfortable to approach them and ask questions. Table 3 shows teachers' perceptions regarding the construct.

Table 3. Summary of teachers' perceptions regarding critical voice

Item	Distribution of responses %		
	Strongly agree/ Agree	Neutral	Disagree/ Strongly disagree
Learners learn that there are different ways to raise questions and seek answers.	84	14	2
Learners feel safe questioning what or how they are being taught.	74	12	14
I feel learners learn better when they are allowed to question what or how they are being taught.	92	6	2
It is acceptable for learners to ask for clarification about activities that are confusing.	98	2	0
It is acceptable for learners to express concern about anything that gets in the way of their learning.	98	0	2
Average	89	7	4

One of the principles of constructivism that was raised as early as 1991 by Caine and Caine is that learning is enhanced by challenge but is inhibited by threat. This means that teachers should not threaten the learners, but rather should create a conducive learning environment. Most of the teachers had constructivist perceptions in this construct since an average of 89% agreed to items under critical voice. This shows that teachers allowed or accommodated learners' ideas if they objected to what was being taught in the classroom instead of taking everything at face value.

4.1.4 Shared control

From a constructivist perspective, the construct shared control is concerned with developing learners' autonomy when learning (Taylor et. al., 1997). It assesses the extent to which teachers go beyond prescribing work activities for learners. The items seek to discover the teachers' perceptions about learners being given opportunities to articulate their goals, involvement in the planning of activities, and assessing those activities. Table 4 shows the distribution of teachers' perceptions.

Table 4. Summary of teachers' perceptions regarding shared control

Item	Distribution of responses %		
	Strongly agree/ Agree	Neutral	Disagree/ Strongly disagree
Learners help me to plan what they are going to learn.	36	18	46
Leaners help me to decide how well they are learning.	56	8	36
Learners help me to decide which activities are best for them.	22	14	64
Learners let me know if they need more/less time to complete an activity.	66	4	30
Average	45	11	44

Compared to all the constructs, shared control had the least preference by teachers with an average of 45%. The teachers' perceptions were that learners should not be involved in planning what they will learn. The findings revealed that teachers were working in teacher-centred environments.

4.1.5 Learner negotiation

The construct learner negotiation refers to learner- to-learner negotiation which involves every learner having an opportunity to express themselves with the audience of other learners. Table 5 shows distribution of teachers' perceptions.

Table 5. Summary of teachers' perceptions regarding learner negotiation

	Distribution of responses %		
Item	Strongly agree/ Agree	Neutral	Strongly disagree/ Disagree
Learners talk among themselves about how to solve problems.	74	10	16
Learners explain their ideas to other learners.	76	6	18
Learners ask other learners to explain their ideas.	74	10	16
Learners are asked by others to explain their ideas.	70	14	16
Average	74	10	16

The findings show that science teachers held positive perceptions for learner negotiation as portrayed in Table 5 where an average of 74% agreed, against only 16% who disagreed to the items under learner negotiation. The following section outlines the results obtained from interviews which were meant to elaborate or authenticate teachers' perceptions obtained from the questionnaire responses.

4.2 How science teachers implemented constructivist teaching strategies in their classrooms

Based on the responses from the questionnaire, only five teachers who showed to be more constructivist than others were interviewed. From the five participants, the researchers managed to determine whether there was a relationship between what teachers perceived about constructivist learning environments, and how they taught in their science classrooms. One major theme emerged from the analysis of data.

Theme: Teachers were knowledgeable about the characteristics of a constructivist learning environment in the science classrooms

When asked about the teaching strategies they used in their classrooms, three of the five teachers King, Lungi and Calvin mentioned cooperative group learning and the use of visuals as teaching strategies. Their teaching focused on learners and not on themselves. They emphasised the importance of learner involvement in the classroom by allowing learners to seek ideas from each other. They did not view themselves as knowledge experts, but they viewed their learners as active participants in the learning process. Their responses were in line with the requirements of a social constructivist classroom. However, Hlayi, the youngest and least experienced teacher indicated traditional tendencies in her responses. Her response to the question regarding teaching strategies she mostly used was, *'I normally use direct instruction, you know, traditional teaching where I impart the knowledge to the learners….'*.

On the other hand, Flo mentioned the importance of eliciting learners' prior knowledge at the beginning of the lesson. She indicated that she probed learners to determine what they knew about the topic under discussion. Overall, class discussion was one of the teaching strategies teachers

mentioned in the interviews, which they said allowed learners to share their ideas. Lungi said that discussions enable learners to deeply engage with the concepts and that learners were more productive during discussions in small cooperative groups. Because social interaction is one of the tenets of social constructivism, King indicated that he used group work which allowed learners to interact, discuss and share ideas. During such interactions, sharing of ideas and negotiation in decision making are enhanced. The teachers' responses corresponded to their responses to questionnaire items on the construct learner negotiation.

When asked whether they allowed learners to participate in decision making, which is one of the constructs found in CLES as shared control, the teachers' responses varied. King pointed out that it would be irresponsible of him to allow learners to freely decide what to do in the classroom because time is an important factor in the completion of the syllabus for examinations purposes. Lungi showed flexibility on this issue as she said that sometimes she allowed learners to make decisions about what activities they could do. She gave an example where her learners failed to understand a particular concept and approached her by asking, *'what if we do an experiment ma'am?'* The teachers also raised the limited autonomy they had in deciding what content to be covered and how much time should be spent as work schedules, assessment tasks, and the times for completion of syllabus, are stipulated by authorities.

Teachers involved in this survey were knowledgeable about the benefits of social interaction as required by social constructivism but were not at ease in involving learners in decision making as indicated in their responses.

Flo: No not at all. Some learners can easily be distracted and may just talk and play with friends. Learners waste time by disturbing others. I will end up not completing the content to be covered in a lesson. So no, I don't allow them to decide on the time.

Calvin: I occasionally allow learners when I really see the need for more time to complete an activity.

Hlayi: No, learners are not given any opportunity to choose classroom activities.

It shows the teachers were not forthcoming when it comes to giving learners autonomy to make decisions. Despite these responses, all the participants described their roles as that of facilitators, which is commensurate with a constructivist classroom where learners are encouraged to be co constructors of knowledge. In certain instances, where teachers identified their role as that of 'more knowledgeable others' in accordance with Vygotsky's ZPD, they came out strongly as portraying learners as passive recipients of knowledge. An example is of Hlayi who said, *"I am the driving force in the classroom. the one who is knowledgeable of the content, and I try to fill in those gaps through explanations".*

During interviews, teachers were also asked about the role of language in science teaching and learning since language is required in the construction of meaning. King said, *"English is a barrier to science learning"*. Flo indicated how learners struggle to differentiate particular words e.g. *'contract'* from *'constrict'*; *'choroid'* from *'chorion'*. This is because the words are foreign to learners as they do not use them in their everyday lives. The teachers indicated that sometimes learners knew the correct answers but failed to express themselves hence reducing the levels of interactions which are the essence of a constructivist learning environment. Four of the teachers, King, Lungi, Flo, and Calvin indicated that they allowed the use of learners' home language in their classrooms and would translate it to English. On the other hand, Hlayi expressed a different opinion when she said, *'I'm not too fond of that because the questions in tests or examinations are in English'.* Her concerns were based on the reality that in most schools English is the language of learning and teaching. She felt that code switching disadvantaged other learners in her classes. The teacher's argument was that learners may become

comfortable with the use of home languages and forget the reality of life since no code switching takes place at tertiary level.

5. Discussion

The findings from CLES questionnaire showed that the teachers perceived their classrooms to be in accordance with many characteristics of constructivist learning environments. Previous studies (e.g. Johnson & McClure 2004; Yore, Anderson & Shymansky, 2005) support the current findings as they also found the teachers' perceptions to be more positive than those of their learners, though learners' perceptions were not investigated in the current study. A point to note is that Unal and Akpinar (2006) indicated that this positivity is however not evident when classroom visits are done, an aspect which could not be obtained in the current study as interviews were conducted instead of lesson observations. The findings showed that teachers were mostly constructivist with regards to personal relevance, which was also well articulated in the interviews. For instance, all five teachers interviewed, agreed on the use of real-life examples to enhance conceptual understanding and to link leaners' experiences with classroom content. Such a finding was also found in the study on students' perceptions of the learning environment and attitudes in game-based mathematics classrooms by Afari et al. (2013) where personal relevance was found to be the strongest determinant of learner outcomes.

The findings on shared control showed that the teachers were still holding traditional perceptions about their classrooms. This finding is consistent with the findings by Cho, Yager, Seo and Park (2010), where teachers rejected shared control. The rejection was because content needed to be covered in time for standardised tests. Other studies show similar trends in that teachers are uncomfortable in letting learners decide activities and lessons. For instance, Haney and McArthur's (2002) study on prospective science teachers' beliefs about constructivist teaching practices, which found that personal relevance, scientific uncertainty, and learner negotiation were implemented more often than shared control. There is need for teachers' change of perspective as they struggle to acknowledge learners' role in the teaching and learning process thereby failing to embrace the shared control construct. An important finding is that most teachers (82%) acknowledged the role of cultural values and opinions in the teaching and learning process. This is unlike the findings Mavuru and Ramnarain (2020) found that, "there is a deficit positioning of learners' socio-cultural practices, experiences and beliefs by some of the teachers" (p. 1068).

In the interviews the teachers articulated a variety of teaching strategies they employed e.g. discussions, cooperative group work, asking open-ended questions, eliciting learners' prior knowledge and linking learners' experiences to new content, which are in line with the constructivist views portrayed in their questionnaire responses. Whilst van Driel et al. (2001) questions the credibility of findings from interviews by arguing that teachers' actions are a more accurate representation of what they know and believe than the usual array of self-reports, in the current study we argue that the triangulation of these teachers' self-reports with findings from questionnaire responses, authenticates the teachers' constructivist practices.

Some of the teachers recognised learners' home languages as tools used to ensure conceptual understanding particularly when learners are not fluent in the medium of instruction. They pointed out that code switching accorded learners an opportunity to interact in the science classrooms since the exclusive use of English failed in that respect. The teachers were aware that learning is a social activity which requires language in accordance with Vygotsky (1978) who showed the intricate link between language and learning. Unlike the findings from a study by Selanik-Ay and Aydogdu (2016) which found the less experienced teachers implementing the principles of constructivism in their classrooms

compared with the more experienced teachers, in the current study, that distinction was not evident. Instead, the challenges the teachers alluded to were in response to the curriculum demands, which failed to give teachers an opportunity to exercise autonomy in their classrooms in terms of time management.

6. Conclusions and Recommendations

This study investigated the extent to which science teachers created constructivist learning environments in their classrooms. The teachers showed strong positive perceptions for personal relevance, critical voice, and learner negotiation. There is need for improvement regarding scientific uncertainty and shared control. The study revealed that science teachers are knowledgeable about constructivist teaching strategies and perceived their environments to be constructivist. They allowed interactions with and between learners through discussions, and they made efforts to elicit the learners' prior knowledge and experiences, which are constructivist teaching and learning strategies.

Findings from the interviews revealed that there are factors that inhibit teachers from fully implementing constructivist strategies. The teachers pointed out that the learners lacked fluency in English, which is the language of learning and teaching. As such, the teachers bemoaned the fact that interaction is compromised in the classroom. Consequently, teachers allowed learners to use their home languages. The study therefore argues that the curriculum prevents teachers from being more creative in their classrooms as they lack autonomy due to time management, content coverage and time tabled assessments and examinations.

A major contribution of the present study is that in as much as teachers may be knowledgeable about constructivist strategies, there are limitations or restrictions that they encounter when it comes to the actual implementation. This comes from contextual factors such as time, the need to complete the curriculum and lack of proficiency in the language of learning and teaching on the part of learners. Such implementation challenges are prevalent in education systems where summative assessment is the main method of evaluating learners for the sake of promotion or progress to the next level. There is a need therefore to re-evaluate such education systems and refocus on teaching for understanding instead of focusing on learner performance in the final examinations.

The study makes an argument that teacher pedagogical skills and use of technology are key to creating constructivist learning environments in science classrooms. Such arguments are informed by the findings that despite teachers having portrayed high affinity for constructivism in their questionnaire responses, they showed that they could not fully implement constructivist teaching strategies in the interview. As such, there was very limited recognition of the importance of digital tools in a constructivist classroom with regards to the strategies teachers mentioned. Hence inquiry-based strategies and technology use should be advanced in a constructivist science classroom. The views of the five teachers who undertook the interviews cannot however be utilised to generalise the teaching strategies used by all science teachers in the country but could apply in classrooms with similar contexts.

Thus said, the study findings provide implications on both pre-service and in-service science teacher professional development providers on the need to equip teachers with the knowledge and skills on inquiry-based pedagogies and use of technology. This is more pertinent now than ever considering that virtual classrooms are becoming a prominent feature because of the COVID-19 pandemic and teachers require the knowledge and skills to create constructivist learning environments in those virtual platforms. There is also a crucial need to reconcile the prescriptive nature of the science curriculum with teachers' autonomy by providing meaningful opportunities for teachers to implement the curriculum without restrictions. Further studies on constructivist learning environments in the science classrooms

may include the analysis of science lesson plans and virtual lesson presentations to determine the levels of constructivist learning environments science teachers create and establish in those classrooms.

Acknowledgements

References

Afari, E., Aldridge, J. M., Fraser, B. J., & Khine, M. S. (2013). Students' perceptions of the learning environment and attitudes in game-based mathematics classrooms. *Learning Environment Research*, 16, 131-150. https://doi.org/10.1007/s10984-012-9122-6

Aldridge, J.M., Fraser, B. J. & Sebela, M.P. (2004). Using teacher action research to promote constructivist learning environments in South Africa. *South African Journal of Education*, *24*(4) 245-253. https://doi.org/10.4314/saje.24i4.24996

Bada, S. O. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education, 5*(6), 66-70.

https://vulms.vu.edu.pk/courses/edu201/downloads/edu%20201%20(assignment%202).pdf

Benudhar, C., & Moumita, M. (2013). Epistemological and pedagogical implications of constructivism: A contemporary contemplation. *Indian Journal of Educational Research,* 2, 82-94.

Bloomberg, L. D., & Volpe, M. (2012). *Completing your qualitative dissertation: A road map from beginning to end*. Los Angeles, Calif: Sage Publications Ltd.

Booyse, C. & Chetty, R. (2016). The significance of constructivist classroom practice in national curricular design. *Africa Education Review, 3*(1), 135-149. https://doi.org/10.1080/18146627.2016.1182296

Caine, R. N., & Caine, G. (1991). *Making connections: Teaching and the human brain*. Association for supervision and curriculum development.

Cho, J., Yager, E. R., Seo, H. A., & Park, D. Y. (2010). Changes in high school teachers' constructivist philosophies. *School Science and Mathematics*, 97(8), 400-404.

https://doi.org/10.1111/j.1949-8594.1997.tb17384.x

Creswell, J. W. (2014*). Research design: Qualitative, Quantitative and mixed methods approaches* (4th ed.). Los Angeles: Thousand Oaks, Sage Publications Ltd.

Creswell, J. W. (2017). Research design: qualitative, quantitative, and mixed methods approaches. USA: Sage Publications Ltd.

Department of Basic education. (2011). *Curriculum and assessment policy statement, further education and training phase, grades 10-12*. Pretoria: Government printers.

du Plessis, P. & Mestry, R. (2019). Teachers for rural schools- A challenge for South Africa. *South African Journal of Education*, 39(1). https://doi.org/10.15700/saje.v39ns1a1774

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25-39.

Fylan, F. Semi-structured interviewing. In J. Miles & P. Gilbert (Eds.). A handbook of research methods for clinical and health psychology. United States: Oxford University Press.

Grayson, D. J. (2010). *Critical issues in school mathematics and science: Pathways to progress.* Academy of science of South Africa.

Hajal, P. (2019). Investigating school teachers' perceptions of constructivist theory: A multiple case study in Lebanon. *PEOPLE: International Journal of Social Sciences, 5*(1), 535-553.

Haney, J. J., & McArthur, J. (2002). Four case studies of prospective science teachers' beliefs concerning constructivist-based teaching practices. *Science Education*, 86(2), 783-802. https://doi.org/10.1002/sce.10038

Honebein, P. C. (1996). Seven goals for the design of constructivist learning environments. *Constructivist learning environments*: *Case studies in instructional design,* 11-24.

https://doi.org/10.1177/1525822X05282260

Isik, A. D. (2018). Use of technology in constructivist approach. *Educational Research and Reviews, 13*(21), 704-711.

Johnson, B. & McClure, R. (2004). Validity and reliability of a shortened, revised version of the Constructivist Learning Environment Survey. *Learning Environments Research*, 7(1), 65-80. https://doi.org/10.1023/B:LERI.0000022279.89075.9f

Jonassen, D. (1999). Designing constructivist learning environments. *In C. M. Reigeluth (Ed.), Instructional design theories and models: A new paradigm of instructional technology* (2nd ed.), 215-240. Washington, DC: Lawrence Erlbaum Associates.

Kaya, H. (2015). Blending technology with constructivism: Implications for an ELT classroom. *Teaching English with Technology, 15*(1), 3-13.

Leech, N.L. & Onwuegbuzie, A. J. (2007). An array of qualitative data analysis tools. A call for data analysis triangulation, *American Psychological Association,* 22(4), 557-584.

Loyens, S. M. M., & Gijbels, D. (2008). Understanding the effects of constructivist learning environments: Introducing a multi-directional approach. *Instructional Science, 36*(5/6), 351–357. https://doi.org/10.1007/s11251-008-9059-4

Marlowe, B. A. & Page, M. L. (2005). *Creating and sustaining the constructivist classroom.* New Delhi: Sage Publications Ltd.

Martin, J. (2006). Social cultural perspectives in educational psychology. In P.A. Alexander & P.H. Winne (Eds.), *Handbook of Educational Psychology* (595-614). Washington, DC: Lawrence Erlbaum Associates Publishers.

Mavuru, L. & Ramnarain, U. (2017). Teachers' knowledge and views on the use of learners' socio-cultural background in teaching Natural Sciences in Grade 9 township classes. *African Journal of Research in Mathematics, Science and Technology Education, 21*(2), 176-186. http://dx.doi.org/10.1080/18117295.2017.1327239

Mavuru, L. & Ramnarain, U. (2020). Learners' socio-cultural backgrounds and science teaching and learning: a case study of township schools in South Africa. *Cultural Studies of Science Education, 15*(4), 1067-1095. https://doi.org/10.1007/s11422-020-09974-8

Mavuru, L. & Dudu, W. (2021). *Advances in inquiry-based science in Zimbabwean schools.* In U. Ramnarain (Ed.), School science practical work in Africa (pp. 32-49). London: Routledge.

Melesse, S. & Jirata, E. (2015). Teachers' perception and practice of constructivist teaching approach: The case of secondary schools of Kamashi zone. *Science, Technology and Arts Research Journal, 4*(4), 194-199. http://dx.doi.org/10.4314/star.v4i4.27

Merriam, S. B. (2002). *Introduction to qualitative research*, 1st ed. San Francisco: Jossey-Bass.

Mutlu, B. V. G. (2011). *An investigation of relationship between pre-service elementary teachers' pedagogical beliefs and their technology integration perception.* Paper presented at the second international conference on New Trends in Education and their Implications, 27-29 April, Antalya-Turkey.

Omodan, B. I. & Tsotetsi, C.T. (2020). Decolonization of knowledge-construction in university classrooms: The place of social constructivism. *African Journal of Gender, Society and Development*, 9(2), 183-204. https://doi.org/10.31920/2634-3622/2020/9n2a10

Phakeng, M. & Moschkovich, J. (2013). Mathematics education and language diversity: A dialogue across settings. *Journal for Research in Mathematics Education, 44* (1), 119 -128. https://doi.org/10.5951/jresematheduc.44.1.0119

Phillips, D. (2000). *Constructivism in education.* Chicago: University of Chicago Press.

Ramnarain, U. (2021). *Inquiry-based learning in South African schools.* In U. Ramnarain (Ed.), School science practical work in Africa, pp. 1. London: Routledge.

Reddy, V., Zuze, T. L., Visser, M., Winnaar, L., Juan, A., Prinsloo, C. H., Arends, F. & Rogers, S. (2015). Beyond Benchmarks: What twenty years of TIMSS data tell us about South African education? *Human Science Research Council.* http://hdl.handle.net/20.500.11910/2004

Saldana, J. (2009). *The coding manual for qualitative researchers*. Los Angeles: Sage Publications Ltd.

Selanik-Ay, T. & Aydogdu, B. (2016). Determination of teacher characteristics that support constructivist learning environments. *Eurasian Journal of Educational Research*, 63, 293-310. https://dx.doi.org/10.14689/ejer.2016.63.17

Taskin-Can, B. (2011). The perceptions of pre-service science teachers concerning constructivist perspectives to teaching. *Journal of Baltic Science Education, 10*(4), 219-228.

Taylor, S. J., & Bogdan, R. (1998). *Introduction to qualitative research methods: A guidebook and resource*. New Jersey: John Wiley & Sons, Inc.

Taylor, P.C. & Fraser, B.J. (1991, April). *CLES: An instrument for assessing constructivist learning environments*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching.

Taylor, P. C., Fraser, B. J., Fisher, D. L., (1997). Monitoring constructivist learning environments. *International Journal of Educational Research*, 27, 293-302. https://doi.org/10.1016/S0883-0355(97)90011-2

Unal, G., & Akpinar, E. (2006). To what extent science teachers are constructivist in their classrooms? *Journal of Baltic Science Education*, 10, 40-56.

Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching, 38*, 137–158. https://doi.org/10.1002/1098-2736(200102)38:2<137::AID-TEA1001>3.0.CO;2-U

Vygotsky, L. S. (1978*). Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Windschitl, M. (2010). A vision educators can put into practice: Portraying the constructivist classroom as a cultural system. *School Science and Mathematics*, 99, 4   https://doi.org/10.1111/j.1949-8594.1999.tb17473.x

Yore, L. D., Anderson, J. O., & Shymansky, J. A. (2005). Sensing the impact of elementary school science reform: A study of stakeholder perceptions of implementation, constructivist strategies, and school-home collaboration. *Journal of Science Teacher Education, 16(1), 65-88.* https://doi.org/10.1007/s10972-005-6989-4