

Teachers' Conceptions of the Constructivist Model of Science Teaching and Student Learning

Almon Shumba

*School of Teacher Education, Faculty of Humanities, Central University of Technology,
Free State, Bloemfontein 9300, South Africa
E-mails: ashumba@cut.ac.za, almonshumba@yahoo.com*

KEYWORDS Radical Constructivism. Science Teaching–Learning Processes. Constructivist Learning Environment Survey (CLES) Questionnaire. Teachers. Zimbabwe

ABSTRACT This study sought to determine how teachers' conceptions of the constructivist view influence: (a) science teaching and thus student learning; (b) the teachers' and students' roles during the science teaching and learning process; and, (c) the science teaching and learning sequence. A convenient sample of 60 teachers on the Bachelor of Education (Primary) Degree programme completed a 66-item questionnaire probe adapted from Constructivist Learning Environment Survey (CLES) questionnaire. Twenty (20) teachers initially included in the original sample of 60 teachers were used in an in-depth class discussion of each item on the questionnaire probe and issues raised were reported as interview data. Descriptive statistics were used employed to present the quantitative data. The study found that most teacher respondents conceptualized that pre-instructional concepts act as a foundation upon which knowledge is constructed in the mind of learners. The study also found that most science teachers do not have a broader view of the constructivist theory. Therefore, science teachers should teach science from students' perceptions and backgrounds but without distorting the principles upon which science is based.

INTRODUCTION

The premise upon which this study was mooted was that the constructivist science view has not received its fair share in teacher education and training. This is because teachers do not seem to consider students' views from their own perceptions and backgrounds since constructivism gives students the stage to construct their own ideas based on their schema (Ausubel 1963 and 1978; Confrey and Kazak 2005; Quale 2002; von Glasersfeld 1995 and 1996; Vygotsky 1978 and 1986). It is by constructing their own ideas that students tell their own stories based on their own schema or perceptions (Ausubel 1963 and 1978; Ausubel et al. 1978; Lerman 1996). The constructivist philosophy to teaching emphasizes that students should play a key role during the teaching and learning process.

This study discusses the types of alternative teaching strategies that the constructivist model offers to the understanding of the learner and learning. As such, this study sought to determine how teachers' conceptions of the const-

ructivist view influence: (a) science teaching and thus student learning; (b) the teachers' and students' roles during the science teaching and learning process; and, (c) the science teaching and learning sequence. In particular, this study uses the proposition of von Glasersfeld's radical constructivist perspective that:

the function of cognition.....serves the subject's organization of the experiential world, not the discovery of an objective ontological reality, is controversial; many critics argue that this denies the existence of physical reality (Quale 2005: 1).

From this perspective, teaching can be viewed as essentially telling a useful and powerful story (Hardy and Taylor 1997; Phillips 2000; Quale 2002, 2004 and 2005) about how students construct their own science knowledge using radical constructivism. Like other forms of constructivism, it must be acknowledged that von Glasersfeld's radical constructivism has its own criticisms and shortcomings.

Radical constructivism holds that individuals construct their own subjective realities, and that 'it is this *construction* of the individual's subjective reality' (von Glasersfeld 1996: 12) rather than the transmission of scientific representations of the observer-independent world, that should be of interest to science educators. As von Glasersfeld (1996: 13) puts it, 'epistemic agents can *know* nothing but the cognitive struc-

*Address all correspondence to:
Professor Almon Shumba
School of Teacher Education, Faculty of Humanities
Central University of Technology, Free State
Private Bag X20539, Bloemfontein 9300.
South Africa.
E-mails: ashumba@cut.ac.za,
almonshumba@yahoo.com

tures they themselves have put together'; that 'the human knower can know only what the human knower has constructed'. In this regard, radical constructivism implies that the knowledge that students construct is their own views of the world. As such, there are no wrong answers because it is their own construction and understanding of their own reality. In addition, von Glasersfeld (1996) explicitly embraces a 'non-transferability thesis' concerning both knowledge and the elementary constituents of cognition itself: the basic elements out of which an individual's conceptual structures are composed and from which the building blocks must be abstracted from the individual experience (p. 22).

The theory known as *radical constructivism* has been proposed and argued in numerous writings of Ernst von Glasersfeld (1984, 1987, 1989, 1995 and 1996). Von Glasersfeld (1987) defines radical constructivism as a *theory of knowledge* that involves two principles: knowledge is actively constructed by the learner, not passively received from the environment, and *coming to know* is a process of *adaptation*. The key principles are: (1) learning is an *active* process in which the learner uses sensory input and constructs meaning out of it or is a constructive process in which the learner is building an internal illustration of knowledge, a personal interpretation of experience (Perkins 1991; Sherman 1995); and (2) people learn to *learn as they learn*: learning consists both of constructing meaning and constructing systems of meaning (Jaworski 2004). Thus, the trend has been the move from a passive view of knowledge towards a more adaptive and active view (Heylighen 1993).

The first proposition is basic to any type of constructivism because it defines knowledge as the 'product of active learning' (Cobern and Loving 2001; Confrey and Kazak 2005; Quale 2002 and 2005; Siegel 2005). This implies that meaningful learning should actively involve learners in the learning process. However, the epistemic position of radical constructivism has become the centre of bitter controversy within the philosophy of science community, with critics charging that it denies the existence of physical reality leading to an extreme relativist position of solipsism, that is, the idea that each of us is free to dream up whatever world we want (Phillips 2000: 41–85). This implies that radical constructivism proposes a consistently phenomenal epistemology, treating *knowledge* and

learning as mutually defining: knowledge is the result or product of learning; learning is the activity that generates knowledge (Phillips 2000). The activity of learning involves two activities: *perception* of sensory and / or emotive input, and *processing* of perceived data in the mind of cognizing individuals (Lerman 1996; Phillips 2000; Quale 2002, 2004 and 2005). In this regard, perception involves at least the following factors: "expectation and filtering (we perceive what we expect or want to perceive); ability to decode the input (language compatibility, relevant pre-knowledge); reflection, abstraction and generalization; memory (the positioning of events in space and time); assimilation and accommodation (in Piagetian sense); interpersonal exchange and discussion; social influences and acculturation; and individual volition, preference and belief" (Quale 2005: 2). Therefore, this data processing of perception by the cognizing subject constitutes an *active construction of knowledge* (Confrey and Kazak 2005; Phillips 2000; Quale 2002, 2004 and 2005) by the learners during the learning process.

Perkins (1991) argues that constructivism has multiple roots in the psychology and philosophy of this century: the developmental perspective of Jean Piaget, the emergence of cognitive psychology by such figures as Jerome Bruner and Ulrick Neisser, and the constructivist perspective of philosophers such as Nelson Goodman. Central to the vision of constructivism is the notion of the organism as '*active*', not just responding to stimuli, as in the behaviourist rubric, but engaging, grappling and seeking to make sense of things. In other words, learners do not simply take in and store information but they attempt to interpret their experiences and build on and test those interpretations. Perkins (1991) also argues that if learning has a constructivist character, then teaching practice must be supportive of the construction process that has to be undertaken by learners by putting learners at the forefront of the learning process. This implies that learners should be in charge of their own learning by being *actively* involved in the learning activities and the teacher's role is to facilitate or guide learners during the learning process (Mwamwenda 2006).

Background

Constructivist theorists maintain that learning is more effective when teachers use construc-

tivist methods that typically involve more student-centered, active learning experiences, more student-student, and student-teacher interactions, and more work with concrete materials and in solving realistic problems (Bernstein 1996; Brousseau 1997; Shuell 1996). This implies that students are in charge of and are actively involved in their own learning with the teacher acting as a facilitator. Students will benefit from such an exercise since they are given the opportunity to discuss and share their own ideas with other students during the learning process. This also implies that students become active participants rather than passive recipients of knowledge from their teacher.

Empirical studies in the field of psychology indicate that humans in general tend to observe only what fits their conceptions and to ignore counter-examples. Results of studies in science education show clearly that students often do not see what is obvious from the point of view of the presenter of the experiment for example (Duit and Treagust 1998). Although it has been acknowledged that students still create their own meaning based on the interaction of their prior knowledge with instruction, the meanings they make may not be the ones the teacher had in mind. No matter how constructivist the instruction, "learners can and do find interpretations that differ from those intended by experts" (Gelman 1994: 502). Thus, teachers may create constructivist experiences for their students based on what they (teachers) consider salient. This implies that students can create any number of meanings or conceptions, intended, expected, or otherwise, out of the same learning experience which differ in some subtle way from those of the teacher.

The constructivist theory does not challenge the practice of science, but confronts the wishes of science head-on, by providing an alternative epistemological paradigm to explain, interpret, and use science as a way of knowing as well as what we have learned through science (Gelman 1994: 503). As already noted elsewhere in this article, the new thinking in science teaching based on radical constructivism (Quale 2002; von Glasersfeld 1995 and 1996) embraces at least the following theses: (a) Knowledge should be conceived not as a representation of an observer-independent world in itself, but rather as a conceptual construct which is 'viable' in the

experiential world of the knowing subject; (b) Knowers can know only what they have themselves constructed, that is, the cognitive structures they have themselves built up; and (c) The basic elements and relations out of which an individual's conceptual structures are composed cannot be transferred from one language user to another, but must be abstracted from individual experience.

It is against this background that this study sought to establish practising primary school teachers' conceptions of the role of the constructivist teaching and learning model as regard how students acquire knowledge, the process of science teaching and learning, the roles teachers and students play in these processes, and the phases in the science teaching and learning process. Thus, the focus of this study is mutually inclusive of teachers' conceptions of: how students acquire science knowledge; science teaching and student learning; both teachers' and students' roles during science teaching and learning sequence.

METHOD

Sample

A convenient sample of 60 qualified primary school teachers and all of them were holders of a three year Diploma in Education from the University of Zimbabwe. All the participants were enrolled on the 2-year-In-Service Bachelor of Education (B.Ed) degree programme at Great Zimbabwe State University and were in the second and final year of study. Twenty-five of these participants were specializing in Mathematics Education. Of these, 18 were male and 7 were female of average age of 25 years. All the participants had 4 to 12 years primary teaching experience. Thirty-five (35) of the participants were specializing in Environmental Science Education (ESE). Of these, 26 were males and 9 were females of an average age of 27 years. All the 60 participants had taught their respective areas of specialization from Grades 1 to 7. Of the 20 participants used in the discussion interview, 14 were male and 6 were female. All participants were expected to be familiar with the principles of constructivism from their initial training and were expected to be using them in their teaching and learning process in schools.

Instrument

A 66-item questionnaire probe was administered which sought to establish respondents' perceptions of the constructivist view. The questionnaire was adapted from Fraser's (1998a and b) Constructivist Learning Environment Survey (CLES). The CLES is a standardized instrument and hence it is reliable and valid. In a constructivist environment, meaningful learning is a cognitive process in which students make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process involves active negotiation and consensus building (Fraser 1998a and b; Taylor et al. 1997). The CLES (Taylor et al. 1995; Taylor et al. 1997) was developed to assist researchers and teachers to assess the degree to which a particular classroom's environment is consistent with a constructivist epistemology, and to assist teachers reflect on their epistemological assumptions and reshape their teaching practice. The CLES adapted for use in this study is specifically designed to solicit information pertaining to teachers' perceptions of the constructivist classroom. The CLES is more of an opinionative, totally dissimilar to the current instrument used in this study. The CLES was adapted only in terms of its forms to focus on teachers' conceptions of knowledge acquisition during the teaching process in the classroom. As such, the current instrument was wholly modified such that nothing of the CLES is portrayed anywhere on the questionnaire used in this study. The data collected using this modified CLES is pilot study data because it was not used before. The CLES was divided into four sections (A, B, C and D). Section A examined the constructivist view of learning of science knowledge during teaching and learning; Section B examined the constructivist model of science teaching; Section C examined students' and teachers' roles in the constructivist model of science teaching and learning; and Section D examined the sequence of science teaching and learning.

Procedure

The subjects were requested to respond to each of the 66 items in the four Sections using a given code. The respondents Agreed (AG), were Undecided (UD) or Disagreed (DA) with

each item and would put a tick (a) against the item in the corresponding column box. Twenty (20) respondents who specialize in Environmental Science Education (ESE) were interviewed in this study. These participants were available during the swart week, a week just before the end of the semester examination. The interview discussion was held in a formal lecture room atmosphere. The interview-cum-lecture discussion took the form of a focused analysis of each of the questionnaire statements in Sections A to D during which only major pertinent issues of concern to this study raised in the discussion, were acknowledged in the subsequent analyses.

Data Analysis

In this study, quantitative data were analysed using descriptive statistics (percentages and tables) and qualitative data collected using interviews were analysed using themes.

Ethical Issues

Permission to administer the questionnaire to the participants was sought from the Ministry of Higher Education and was granted. Informed consent was obtained from all the participants. The aim and purpose of the study was explained to all the participants. It was impressed upon them that their participation was voluntary and that the information collected was confidential.

RESULTS

Data were analysed based on the adapted CLES instrument used in this study. The analysis acknowledged the overall difference between the difference between responses (CR-AG) and the difference between the responses (CR-DA) with a 45 (75 %) response rate or more as well as the overall difference between the responses (ICR-AG). Based on the CLES instrument, the difference between the incorrect and disagree responses (ICR-DA) or conceptions with a 5 (25 %) response rate acknowledged that conceptions (MC) and undecided (UD) responses were revealed in each of the 66 items (see Table 1). In the ensuing analysis and discussions, responses are indicated for each item number with percentage response rate in brackets (Item number: percentage).

Table 1: Response Summary (N = 66)

Section	A	B	C	D	Total
(T) Responses	10	5	13	15	43 (65.15%)
(F) Responses	6	5	7	5	23 (34.85%)
Total	16	10	20	20	66(100.00%)

Section A: Teachers' Conceptions of the View of Acquisition of Knowledge during Science Teaching and Learning

From the difference between responses (CR-AG), respondents identified that: (a) students' pre-instructional concepts play a key role in knowledge acquisition (1.1:83.3 %); (b) the primary question of the Constructivist epistemology is "How do students come to know what they know? (1.5:80 %); (c) the acquisition of new (science) knowledge is very much influenced by conceptions already held (1.6:80 %); (d) knowledge is not necessarily assumed to fit reality the way a key fits a lock (1.10:78.3 %); and (e) knowledge is constructed in the mind of the student (1.13:80 %). Teacher respondents appear to have conceptualized quite firmly how pre-instructional concepts act as the foundation upon which knowledge is constructed in the mind of learners although knowledge does not necessarily fit reality the way a key fits a lock.

Using the difference between responses (ICR-AG) on their conceptions, some respondents indicated that: (a) conceptions do not always guide observations or determine understanding (1.3:25 %); (b) knowledge about the outside is not viewed as human construction (1.7:25 %); (c) knowledge does not correspond to an iconic image or picture of the real world (1.14:35.6 %); and (d) knowledge can never be based on students' perceptions of reality (1:15:25 %).

Section B: Teachers' Conceptions of the Constructivist Model of Science Teaching and Learning

Participants overwhelmingly identified that: (a) the most important single factor influencing learning is what the student already knows (2.2:75 %); (b) knowledge is good if and when it works, if and when it allows us to achieve our goals (2.7:75 %); (c) the data students perceive from their senses and the cognitive structures or schemes they use to explain these data, both exist in their minds (2.8:75 %); and (d) the process of constructing meaning always is embedded in a

particular setting of which the student is part (2.10:86.7 %). Teacher respondents appeared to have conceptualized quite firmly how pre-instructional concepts act as the foundation upon which knowledge is constructed in the mind of learners. This implies that learners' prior knowledge is very important in learning any new information during the learning process.

Section C: Teachers' Conceptions of Students' and Teachers' Roles in the Constructivist Model of Science Teaching and Learning

Respondents indicated that: (a) there is a two-dimensional flow of information between teachers and their students (3.2:76.7 %); (b) teacher is viewed as a guide in students' individual process of knowledge construction (3.7:86.7 %); (c) the constructivist classroom atmosphere is more satisfying for many teachers and many students (3.11:81.7 %); (d) this teaching and learning model draws from the old pedagogical principle that involves starting to teach from the student's view point (3.15:83.3 %); and (e) the only way to replace a conception held by a student is by constructing a new concept that more appropriately explains the student's experiences (3.17:85 %). Teacher respondents appeared to have a clear understanding of the roles of both teachers and learners during a constructivist setting that lead to both sides benefiting in the process.

Section D: Teachers' Conceptions of the Constructivist Sequence of Science Teaching and Learning

The majority of teacher respondents confirmed the notions that during the restructuring phase students' and teachers' ideas can be: (a) clarified (4.2.1:86.7 %); and exchanged through discussion with others in class (4.2.3:80 %); (b) students have the opportunity to consolidate new conceptions by using them in both familiar and novel situations (in the application phase) (4.3.1:85 %); and (c) elicitation of students' concepts involves "exploring their own ideas" (4.4.1:86.7 %). It should be acknowledged that most teacher respondents agreed with these conceptions of constructivism of science teaching and learning.

Some notable conceptions were revealed in eight of the items in Section D, viz., (a) during the restructuring phase, students' and teachers'

ideas can be promoted in terms of co-nceptual conflict through use of disconfirming experiment or demonstration (4.2.4:26.7 %); and/or (b) introduced by either the teacher or student and the different scientific ideas evalu-ated against experience, through experiment or by understanding their implications (4.2.5:25 %); (c) elicitation of students' conceptions involves; discussing the differences among ideas of dif-ferent students (4.4.2:15 %); and (d) carrying out experiments (4.4.43:23.3 %); and (e) the danger in the contrasting of students' ideas and the science concept is that: students could be unable to see the differences between their view and the new one (4.5.1:31.7 %).

DISCUSSION

The study findings using the adapted CLES instrument revealed that (a) students' pre-instructional concepts play a key role in knowledge acquisition; (b) the acquisition of new (science) knowledge is very much influenced by conceptions already held; (c) knowledge is not necessarily assumed to fit reality the way a key fits a lock; and (d) knowledge is constructed in the mind of the student. These findings are consistent with literature (Ausubel 1963 and 1978; Confrey and Kazak 2005; Quale 2002; von Glasersfeld 1995 and 1996; Vygotsky 1978 and 1986), because teachers do not seem to consider students' views from their own perceptions and backgrounds. Constructivism gives students the stage to construct their own ideas based on their schema (Ausubel 1963 and 1978; Quale 2002; von Glasersfeld 1995 and 1996).

Secondly, the study revealed that: (a) the most important single factor influencing learning is what the student already knows; (b) knowledge is good if and when it works, if and when it allows us to achieve our goals; (c) the data students perceive from their senses and the cognitive st-structures or schemes they use to explain these data, both exist in their minds; and (d) the process of constructing meaning always is embedded in a particular setting of which the student is part. These findings imply that learners' prior knowledge is very important in learning any new information during the learning process. These findings are consistent with the findings of Ausubel (1963 and 1978), Ausubel et al. (1978 and 1986). Hence, it is by constructing their own ideas that students tell their own stories based on their own schema or perceptions.

Thirdly, the study revealed that: (a) there is a two-dimensional flow of information between teachers and their students; (b) teacher is viewed as a guide in students' individual process of knowledge construction; (c) the constructivist classroom atmosphere is more satisfying for many teachers and many students; (d) this teaching and learning model draws from the old pedagogical principle that involves starting to teach from the student's view point; and (e) the only way to replace a conception held by a student is by constructing a new concept that more appropriately explains the student's experiences. The findings are consistent with the literature (Quale 2002; von Glasersfeld 1996).

Finally, the study also revealed that: (a) during the restructuring phase, students' and teachers' ideas can be promoted in terms of conceptual conflict through use of disconfirming experiment or demonstration; and/or (b) introduced by either the teacher or student and the different scientific ideas evaluated against experience, through experiment or by understanding their implications; (c) elicitation of students' conceptions involves; discussing the differences among ideas of different students; and (d) carrying out experiments; and (e) the danger in the contrasting of students' ideas and the science concept is that: students could be unable to see the differences between their view and the new one. The above findings are consistent with literature (Hardy and Taylor 1997; Phillips 2000; Quale 2002, 2004 and 2005).

The group interview-cum-lecture discussion was conducted during a lecture to compare teachers' views with responses made in the questionnaire used in this study. The sentiments expressed during the discussion provide some data that enhance our knowledge of teachers' difficulties in accepting that students have the ability and potential to construct knowledge (Ausubel 1978; Quale 2002; von Glasersfeld 1995 and 1996; Vygotsky 1978 and 1986). Some of the sentiments expressed by these participants include: (a) the constructivist view assumes that every student must have undergone some "formal" pre-instructional experiences to enhance their ability to co-ordinate their constructs into a holistic cognitive structure or scheme; (b) the probability of individual students constructing some more or less uniform conception (groups sharing common identical knowledge) that is in accord with science conception is very minimal;

and (c) the analysis of concept development from this perspective, is the constructivist's conception of students' concept construction which can be interpreted differently from a constructivist's; non-constructivist's, teachers'; and students' perceptive.

In response to items in Section B, the group discussion revolved around the traditional methods of teaching and hence learning as conceived of by "traditional" teachers. Respondents argue that: (a) students sometimes come to class as "empty vessels to be filled with knowledge" in the event that some new concepts, totally alien from the pre-instructional or indigenous (socio-cultural) experiences are introduced. For example, students may not find anything to fall back on when introduced to concepts such as, "Ozone hole", "photochemical smog", or "geothermal power". Teacher must therefore "fill the empty vessels". (b) we have often taught and taught well with students learning and passing in their examinations extremely well, by simply "transferring nuggets" of information into students' minds – an observation that confirms that teaching and learning are synonymous, the former activating the latter; and (c) since constructivist teaching appears to give students the latitude to learn at their own pace (Hardy and Taylor 1997; Phillips 2000; Quale 2005), the model should have negative academic and professional impacts on the teaching and learning of examination oriented classes.

Misunderstandings of the status of the students' conception of science appear to play a key role in influencing teachers' conceptions of how students learn how to learn. While teachers, through their own college science education and science teaching experiences have acquired a long-term perspective of placing a single experiential event within a structured sequence of related concepts, they deny students such a long-term perspective (Quale 2002; Vygotsky 1986). It would appear that teachers were still struggling to understand the nature of cognitive structures students use to construct and relate new science knowledge.

In response to items in Section C, the discussion group voiced three major sentiments of concern: (a) the symmetrical relationships assumed to exist between an individual student and the teacher and among the students and the teachers are hypothetical and unattainable. Such a situation defies the traditional socio-cultural

norms (of elders know best through experience) and would invariably undermine the role of the teacher as the "leader" and "guide" in students' individual knowledge construction process; (b) the process of changing from students' conceptions to science conceptions must of necessity be in harmony with students' world view to enhance the process of enculturation. If the two processes are at variance, the student may be forced to replace his/her traditional (pre-instructional or indigenous experiences) conception with that of science. Thus, according to Adams (1999) becoming assimilated into a scientific subculture – a process involving a "coming over", some form of "border crossing" that often militates against science knowledge construction; and (c) besides, the teacher's attempts at students' conceptual change would have to transcend a range of traditional worldviews such as anthropomorphism, spiritual forces, animism and mysticism that students hold and are remarkably resistant to science instruction (Perkins 1991; Phillips 2000). That teacher respondents continue to cling on to "the teacher knows it all" status becomes very apparent among the respondents. This kind of thinking is contrary to the constructivist philosophy where learners are actively involved in their learning (Quale 2004 and 2005).

In response to items in Section D, an endless circle of misunderstanding is bound to occur in such communication situations during science teaching and learning. For instance, students frequently form some sort of integration of their pre-instructional conceptions with new taught science concepts, but usually their pre-conceptions are not altered seriously. From the foregoing, it becomes evident that what the teacher may classify as a student's wrong answer (misconception) may be his/her construction on the basis of his or her conception. Hence, teachers should be reminded that students argue from a vantage point that is different from theirs. As Treagust et al. (1996) put it, what researchers (teachers) call students' conceptions are actually the researchers' (teachers') conceptions of the students' conceptions. Thus, for a student to experience conceptual change, the student's conceptual ecology provides the context in which conceptual change occurs, influences the change, and gives it meaning. This implies that conceptual growth would entail the enlargement of the conceptual network in such a way that the

student's previous (prior) knowledge and its connections, for the most part, would remain intact (Ausubel 1963 and 1978). Viewed from this perspective, the aim of science instruction is not to erase students' conceptions, but to work out the contexts in which these conceptions are limited and in which the science conceptions are more valuable.

There is no doubt that radical constructivism as epistemology and as a theory or model of instruction have its strengths and weaknesses. It makes too many assumptions about the roles of the key players (learners and teachers) during the learning process because of its inductivist and simplistic view of conceptual change. It has the tendency to construe learning as simply replacing learners' misconceptions/alternative conceptions with canonical or orthodox scientific understandings. It also appears to regard all forms of conceptual change as equally difficult and likely to be ameliorated by one omnibus, constructivist pedagogy. Constructivists also make a general assumption that getting learners to be busy with activities necessarily amounts to active learning as if the mind can ever be really passive (Quale 2002; von Glasersfeld 1995 and 1996; Vygotsky 1978 and 1986). Its relativist posture about the reversionary nature of science fails to consider that scientific ideas do not change at the whims and caprices of scientists, that is, most scientific ideas are not likely to change much in the nearest future. An approach of teaching is independent from the natural principles of science. The approach helps the student to learn the scientific concepts better from their own construction of the world or reliability.

CONCLUSION

There is no doubt from the findings of this study that teachers' conceptions of how students acquire science knowledge affirms teachers' limited knowledge of cognitive structures that students use to construct and relate their pre-instructional experiences to new science knowledge. As such, if students' knowledge construction is based on their own schema and perceptions, then teachers need to see students' perceptions as their own conceptions of science knowledge (Ausubel 1963 and 1978). In conclusion, therefore, students' knowledge should be considered as fact since this is new know-

ledge constructed from their own schema and perceptions. This makes learning to be more challenging and meaningful to students during the teaching and learning process in the classroom.

RECOMMENDATIONS

The conceptions revealed by the questionnaire probe that sought teachers' conceptions of; the constructivist view of knowledge acquisition, models of science teaching and learning, the teachers' and students' roles in science teaching and students learning and the constructivist science teaching and learning sequence, all have implications for science education and teacher training programme in Zimbabwe. It is against this background that the following suggestions are considered critical: (a) Teachers on the in-service Bachelor of Education Degree programme need to revisit the major tenets of the constructivist theory to enhance their conception of its social and radical implications of this view so as to accommodate the conceptions that they hold concerning science teaching and student learning. This will help these teachers to have a broader view of this theory and to see issues from other perspectives other than theirs only. For example, the study found that most teacher respondents appear to have conceptualized that pre-instructional concepts act as a foundation upon which knowledge is constructed in the mind of learners (Quale 2002; von Glasersfeld 1995 and 1996; Vygotsky 1978 and 1986). This implies that teachers should also consider students' perspectives since these are based on their own perceptions and backgrounds. (b) Science teachers should be encouraged to teach science from the student's point of view rather than from their (or scientist's) point of view, as this allows the students to fall back on their pre-instructional, socio-cultural or indigenous experiences during their science knowledge construction process. This helps students to understand science learning from their own perceptions, schema and conceptions. (c) There is a dire need to enhance teachers' knowledge of science as a socially constructed activity. This is because teachers have often tended to validate students' science conceptions against their own knowledge construction rather than against conceptions of the community of scientists (Confrey and Kazak 2005; Von Glasersfeld 1996). Besides teachers' science co-

nceptions may be at variance with those of the scientists.

REFERENCES

- Ausubel D 1963. *The Psychology of Meaningful Verbal Learning*. New York: Grune and Stratton.
- Ausubel D 1978. In defense of advance-organizers: A reply to the critics. *Review of Educational Research*, 48: 251–257.
- Ausubel D, Novak J, Hanesian H 1978. *Educational Psychology: A Cognitive View*. 2nd Edition. New York: Holt, Rinehart & Winston.
- Bernstein B 1996. *Pedagogy, Symbol Control and Identity: Theory, Research, Critique*. London: Taylor and Francis.
- Brousseau G 1997. *Theory of Didactical Situations in Mathematics*. Dordrecht: Kluwer Academic Publishers.
- Coburn WW, Loving CC 2001. In Defense of Realism: It Really is Commonsense. Scientific Literary and Cultural Studies Project Working Paper #163. Paper Presented at the Tri-Annual International History, Philosophy and Science Teaching Group Meeting, 7 – 11 November 2001. Denver: CO.
- Confrey J, Kazak S 2005. A thirty-year reflection on constructivism in mathematics education in PME. In: A Gutierrez, P Boero (Eds.): *Handbook of Research on the Psychology of Mathematics Education: Past, Present and Future*. Rotterdam/ Taipei: Sense Publishers, pp. 305–346.
- Duit R, Treagust DF 1998. Learning in science – From behaviourism towards social constructivism and beyond. In B Fraser, K Tobin (Eds.): *International Handbook of Science Education*. Dordrecht, The Netherlands: Kluwer Academic Publishers, pp. 3–26.
- Fraser BJ 1998a. Science learning environments: Assessment, effects and determinants. In: BJ Fraser, KG Tobin (Eds.): *International Handbook of Science Education*. Dordrecht, The Netherlands: Kluwer, pp. 527 – 564.
- Fraser BJ 1998b. Classroom environment instruments: Developing, validity and applications. *Learning Environments Research*, 1: 7–33.
- Gelman R 1994. Constructivism and supporting environments. In: D Tirosh (Ed.): *Implicit and Explicit Knowledge: An Educational Approach*. Norwood, N.J.: Ablex Publishing Corporation, pp. 55 – 82.
- Hardy MD, Taylor PC 1997. Von Glasersfeld's radical constructivism: A critical review, *Science and Education*, 6: 135–150.
- Heylighen F 1993. Epistemology: Introduction 2004. From <<http://pespmc1.vub.ac.be/EPISTEM.html>> (Retrieved on September 16, 2010).
- Jaworsky B 2004. Constructivism and Teacher: The Socio-cultural Context. From <<http://www.grout.demon.co.uk/Barbara/chreods.html>> (Retrieved on September 16, 2010).
- Lerman S 1996. Inter-subjectivity in mathematics learning: A challenge to the radical constructivism paradigm? *Journal for Research in Mathematics Education*, 27(2): 133–135.
- Mwamwenda TS 2006. *Educational Psychology: An African Perspective*. 3rd Edition. Sandton: Heinemann.
- Perkins D 1991. What constructivism demands of the learner. *Educational Technology*, 39(9): 9 – 21.
- Phillips DC 2000. *Constructivism in Education*. (Ninety-ninth Yearbook of the National Society for the Study of Education) Chicago: University of Chicago Press.
- Quale A 2002. The role of metaphor in scientific epistemology from a constructivist perspective: Consequences for science education. *Science and Education*, 2(1–2): 25–33.
- Quale A 2004. *Telling a Story: The Role of Radical Constructivist Epistemology in Science Education*. Norway: University of Oslo.
- Quale A 2005. Radical Constructivism and the Sin of Relativism. Paper Presented at the International Conference on Science Education and Its Implications for Constructivism, Multiculturalism and Postmodernism held at the University of Leeds, England, 15 – 18 July, 2005.
- Sherman LW 1995. A postmodern, constructivist and cooperative pedagogy for teaching educational psychology, assisted by computer mediated communications. In: JL Schnase, EL Cunnius (Eds.): *Proceedings of CSCL 1995: The First International Conference on Computer Support for Collaborative Learning*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., pp. 308 – 311.
- Shuell T 1996. Teaching and learning in a classroom context. In: D Barliner, R Calfee (Eds.): *Handbook of Educational Psychology*. New York: Macmillan, pp. 726 – 764.
- Siegel H 2005. *The Bearing of Philosophy of Science on Science Education, and Vice Versa: The Case of Constructivism*. Department of Philosophy, University of Miami. Coral Gables, USA.
- Taylor PC, Dawson V, Fraser BJ 1995. Classroom Learning Environments Under Transformation: A Constructivist Perspective. Paper presented at the annual meeting of the American Educational Research Association. San Francisco: CA.
- Taylor PC, Fraser BJ, Fisher DL 1997. Monitoring constructivist classroom learning environments. *International Journal of Educational Research*, 27: 293 – 302.
- Treagust DF, Duit R, Fraser BJ 1996. *Teaching and Learning of Science and Mathematics*. New York: Teachers College Press.
- Von Glasersfeld E 1984. An introduction to radical constructivism. In: P Watzlawick (Ed.): *The Invented Reality*. New York: W.W. Norton and Company, pp.17–40.
- Von Glasersfeld E 1987. Learning as a constructive activity. In: C Janvier (Ed.): *Problems of Representation in the Teaching and Learning of Mathematics* New Jersey: Lawrence Erlbaum Associates, Inc., pp. 3 – 17.
- Von Glasersfeld E 1995. *Radical Constructivism: A Way of Knowing and Learning*. Washington, D.C.: The Falmer Press.
- Von Glasersfeld E 1996. Introduction: Aspects of constructivism. In: C Fosnot (Ed.): *Constructivism: Theory, Perspective and Practice*. New York: Teachers College Press, pp. 3 – 7.
- Vygotsky L 1978. *Mind in Society: The Development of Higher Psychological Processes*. MA: Harvard University Press.
- Vygotsky LS 1986. *Thought and Language*. Cambridge, MA: MIT Press.