South African Grade 11 Physical Sciences perceptions of scientific inquiry

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Abstract. This study explored South African Grade 11 Physical Sciences learners' perceptions of scientific inquiry within the context of science classrooms. The study adopted a mixed method approach as part of an exploratory descriptive survey design and involved 50 purposively selected Grade 11 physical sciences learners from 3 South African township schools. Quantitative data was collected by administering a validated Learner Perceptions of Classroom Inquiry (LPCI) instrument with the participants. Qualitative data was collected through semi-structured interviews. The study revealed that the learners held mixed conceptions about the nature of scientific inquiry. A substantial number of learners held naïve and incoherent views about the nature of scientific inquiry. Lack of practical laboratory lessons, lack of well-equipped science laboratories, inadequate teacher professional competence when conducting scientific investigations, and limited opportunities for meaningful engagement in inquiry-based learning activities were perceived to be contextual factors that serve to hinder meaningful enactment of scientific inquiry in science classrooms. The findings have profound implications for meaningful enactment of contemporary pedagogic approaches such as inquiry-based learning in diverse contexts. Theoretical implications for coherent development of scientific literacy through meaningful enactment of scientific inquiry within the broader South African educational context are discussed.

1. Introduction

The Curriculum and Assessment Policy Statement (CAPS) promulgated by the South African Department of Basic Education (DBE) advocates that the teaching and learning of science ought to engage learners to perform scientific investigations, identify, analyse and solve problems, design and evaluate solutions and then apply the knowledge in new contexts [1]. Scientific inquiry provides opportunities to enhance understanding in a process of testable illustrations and explanations that learners can utilize to guess the outcome of subsequent investigations. This empowers learners or scientists to acquire a greater perception of the subject or topic they may be studying thereby making use of the understanding in other science topics by following the science process. Scientific inquiry is widely accepted as a method of science teaching. Understanding the characteristics of the Nature of Scientific Inquiry (NOSI) is also necessary for a whole conception of scientific inquiry [2]. This study explored Grade 11 Physical Sciences learners' perceptions of their experiences of scientific inquiry within the context of science classrooms at three South African township schools.

In the knowledge-based economy, “learning-by-doing” is paramount, and inquiry-based learning activities could encapsulate experiences that develop thinking skills needed in the workplace. These new demands from the workplace and the technological advancements of the world in which we live served to stimulate much change in national curricula throughout the world [3]. In terms of the Next Generation Science Standards (NGSS), students are expected to demonstrate understanding by developing and constructing models, planning and carrying out investigations, constructing explanations, analyzing and interpreting data sets, providing evidence, and using argumentation to substantiate findings [4]. Hence, scientific inquiry is synonymous with a vision of scientific literacy that encompasses skills and knowledge related to scientific and engineering practices [5].

2. Research design and methodology

The study adopted a mixed method approach as part of an exploratory descriptive survey design. Population and sampling. For this study, the target population comprised of Physical Sciences learners from three township schools in the Gauteng West District located in the Gauteng Province of South Africa. The study involved 50 purposively selected Grade 11 Physical Sciences learners as participants. Table 1 below provides a breakdown in terms of the number of participants from each school.

Table 1. Number of participants from each school.

School	Type of school	Number of participants
A	Township School	16
B	Township School	17
C	Township School	17

3. Results

3.1 Findings emanating from quantitative data

Table 2 below provides the distribution of responses to the questionnaire. The counts (frequencies) and percentages are determined for each of the items based on participants’ responses. Majority of the learners (58%) indicated that they were afforded opportunities to ask frame research questions in a science classroom while 42% of the learners indicated that they have not been afforded such opportunities. While 54% of the learners were not exposed to formulation of questions which can be answered by investigations, 46% of the learners were exposed to such an activity as part of the enactment of scientific inquiry. The learners provided varied responses to the item “My research questions are used to determine the direction and focus of the lab”. Responses to this item indicate that learners’ research questions were not taken into account when determining the direction and focus of the laboratory activities. A considerable number of learners (68%) appreciated the importance of framing their own questions when conducting scientific investigations. The learners devoted time to refine their questions so that they can be answered by the investigation. This sentiment was expressed by 52% of the learners. the findings emanating from quantitative data demonstrated that when enacting scientific inquiry, Physical Sciences learners at selected schools were afforded limited meaningful opportunities to ask framing research questions in the science classroom, design investigations in the science classroom, conduct investigations in the science classroom, collect data in the science classroom, and draw conclusions in the science classroom. This deficiency in teacher professional practice can be attributed to teacher commitment to traditional instruction which is not compatible with the dictates of meaningful enactment of scientific inquiry. These findings point the need for sustainable teacher professional development interventions which are geared towards the enhancement of professional practice on meaningful enactment of contemporary pedagogical approaches such as inquiry-based learning. The development of scientific literacy would be severely restricted if appropriate systems are not put in place to implore teachers as key agents of educational change to fully embrace pedagogic innovation with a view to create conducive, dynamic and intellectually stimulating teaching and learning environments. Coherent realization of this key strategic imperative requires commitment on the part of South African Department of Basic Education to provide meaningful platforms which promote transformation of teacher professional practice in its broadest sense.

Table 2. Distribution of responses.

Items	Almost never		Seldom		Sometimes		Often		Almost always	
	Count	Row Valid N %	Count	Row Valid N %	Count	Row Valid N %	Count	Row Valid N %	Count	Row Valid N %
Learners ask framing research questions in the science classroom										
I formulate questions which can be answered by investigations	13	26.0%	14	28.0%	12	24.0%	6	12.0%	5	10.0%
My research questions are used to determine the direction and focus of the lab	14	28.0%	13	26.0%	5	10.0%	13	26.0%	5	10.0%
Framing my own questions is important	7	14.0%	9	18.0%	10	20.0%	8	16.0%	16	32.0%
Time is devoted to refining my questions so that they could be answered by investigations	11	22.0%	13	26.0%	8	16.0%	11	22.0%	7	14.0%
Learner designs investigations in the science classroom										
I am given stepwise instructions before they conduct investigations	3	6.0%	5	10.0%	15	30.0%	10	20.0%	17	34.0%
I design my own procedures for investigations	23	46.0%	7	14.0%	18	36.0%	2	4.0%	0	0.0%
We engage in the critical assessment of the procedures that we employ when conducting investigations	10	20.0%	5	10.0%	13	26.0%	19	38.0%	3	6.0%
We justify appropriateness of the procedures that are employed when we conduct investigations.	10	20.0%	5	10.0%	7	14.0%	24	48.0%	4	8.0%
Conducting investigations in the science classroom										
I conduct my own procedures of an investigations	17	34.0%	13	26.0%	3	6.0%	13	26.0%	4	8.0%
The investigation is conducted by the teacher in from of class	4	8.0%	11	22.0%	8	16.0%	8	16.0%	19	38.0%
I actively participate in investigations as they are conducted	7	14.0%	16	32.0%	7	14.0%	11	22.0%	9	18.0%
I have a role as investigations are conducted	23	46.0%	3	6.0%	9	18.0%	7	14.0%	8	16.0%

Collecting data in the science classroom										
I determine which data to collect	27	54.0%	3	6.0%	18	36.0%	2	4.0%	0	0.0%
I take detailed notes during each investigation along with other data I collect	8	16.0%	7	14.0%	9	18.0%	19	38.0%	7	14.0%
I understand why the data I am collecting is important	10	20.0%	5	10.0%	7	14.0%	24	48.0%	4	8.0%
I decide when data should be collected in an investigation	12	24.0%	13	26.0%	14	28.0%	5	10.0%	6	12.0%
Drawing conclusion in the science classroom										
I develop my own conclusion for investigation	4	8.0%	12	24.0%	11	22.0%	6	12.0%	17	34.0%
I consider a variety of ways of interpreting evidence when making conclusions	9	18.0%	15	30.0%	8	16.0%	11	22.0%	7	14.0%
I connect conclusions to scientific knowledge	21	42.0%	5	10.0%	7	14.0%	7	14.0%	10	20.0%
I justify my conclusions	2	4.0%	5	10.0%	12	24.0%	13	26.0%	18	36.0%

3.3 Findings emanating from qualitative data

Findings emanating from qualitative data are clustered according to the themes that emerged during data analysis. The themes are: enactment of scientific inquiry, available infrastructure and resources, and contextual factors influencing the enactment of scientific inquiry in science classrooms.

Theme 1: Enactment of scientific inquiry in science classrooms

The enactment of scientific inquiry at the selected schools appeared to be teacher-centred. Limited opportunities were provided for learners to design investigations in the science classroom. Learners were not at liberty to design their own procedures for investigations as required by the nature of scientific inquiry. This sentiment is reflected in the following excerpt.

> "We are not given the chance to be imaginative and creative when doing investigations in the classroom. The teacher does everything"

At another pragmatic level, learners bemoaned lack of meaningful opportunities to ask framing research questions in the science classroom when performing scientific investigations. Yet, framing research questions is central to the design of scientific investigations. These concerns are captured in the following excerpt.

> "Sometimes it is difficult to understand the research questions informing the scientific investigation performed in class. This understanding is important for us as learners."

While learners appreciated the importance of data collection as an integral part of scientific investigations, they bemoaned lack of opportunities to independently determine the type of data to collect. Learner autonomy is a key ingredient for fostering the development of investigation skills. Concerns expressed in this regard are encapsulated in the following excerpt.

> "The teacher tells us everything about data collection and the scientific phenomenon to be investigated. We follow the recipe approach when performing scientific investigations in our classroom."

Theme 2: Available infrastructure and resources

Township schools are generally under-resourced and this state of affairs adversely affects provision of quality education within the broader South African context. More specifically, general lack of resources has a detrimental impact on meaningful enactment of inquiry in science classrooms. Sentiments expressed by the participants in relation to this state of affairs are reflected in the following excerpt.

> "We don't have any labs at school, usually Mam does the experiments. Teachers improvise with little resources that we have. We don't have labs, often chemicals used are outdated. Teachers try to involve us and set apparatus as groups."

Theme 3: Contextual factors influencing the enactment of scientific inquiry in science classrooms

The implementation of scientific inquiry at the selected township schools appeared to be influenced by a myriad of contextual factors. These factors included general lack of infrastructure and resources, lack of teacher professional competence on the enactment of scientific inquiry, adoption of teacher-centred approaches, language as a barrier in science learning, and lack of meaningful opportunities for learners to engage in deep learning. Concomitant sentiments expressed in this regard are captured in the following excerpt.

> "The teacher does not give us chance to actively participate when doing scientific investigation. We want to be imaginative and creative when we take part in the activities. Sometimes working in groups is not nice because you cannot do the investigation independently. But, lack of laboratory resources is a problem."

4. Discussion

The study uncovered inadequacies associated with the enactment of scientific inquiry at selected South African township schools. General lack of resources at township schools appears to have a detrimental impact on meaningful enactment of inquiry in science classrooms. In most schools, poor infrastructure and resources limit learners' engagement in inquiry-based activities and by extension the opportunity to understand the nature of scientific inquiry [6]. The use of language appeared to be a barrier to meaningful enactment of inquiry in science classrooms. Instructional language serves as a barrier to students' performances in Physical Sciences [7]. Meaningful enactment of inquiry-based learning as a contemporary pedagogic approach remains a fundamental challenge to teachers as key agents of educational change within the broader South African context. The views expressed by learners about the nature of scientific inquiry point to extensive exposure to instructional settings providing limited opportunities for learner autonomy when performing scientific investigations. Such instructional settings essentially serve to stifle meaningful development of inquiry skills required to perform plausible scientific investigations. The development of learners' knowledge about scientific inquiry remains a key science education curriculum goal. Yet, many secondary school learners continue to demonstrate naive understandings about scientific inquiry [8]. Meaningful enactment of scientific inquiry was largely hampered by a myriad of contextual factors. These factors included general lack of infrastructure and resources, lack of teacher professional competence on the enactment of inquiry, adoption of teacher-centred approaches, language as a barrier in science learning, and lack of meaningful opportunities for learners to engage in deep learning.

By its very nature, enactment of inquiry provides learners with opportunities to grapple with scientific data, make observations, draw conclusions, provide explanations for evidence and communicate findings [9]. However, it must not be assumed that when learners engage in or do scientific inquiry, they automatically understand the NOSI [10]. Teachers should not only engage learners in investigations, but should also provide them with explicit/reflective instruction on the rationale for every inquiry action for learners to understand the process through which scientists generate knowledge [11]. It is believed that such an approach essentially serves to develop learners' scientific inquiry skills as well as the understanding of the nature of scientific evidence and knowledge.

5. Conclusion

The study demonstrated that learners at selected township schools held fragmented and mixed views about the nature of scientific inquiry as a result of the inadequacy of traditional instruction. The enactment of scientific inquiry was largely characterized by the adoption of teacher-centred approaches which are not compatible with the development of scientific inquiry skills. There is a critical need to enhance teacher professional capacity required for meaningful implementation of contemporary pedagogic approaches such as inquiry-based learning.

6. References

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