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Implementation of learners' science process skills by primary school teachers in the Lejweleputswa District of South Africa: A case study

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Abstract

This research explores teachers' perceptions of the development of learners' science process skills through the implementation of inquiry-based approaches in Thabong primary schools in the Lejweleputswa District, South Africa. Its aim was to find effective teaching methods using inquiry-based approaches to develop learners' science process skills and improve their scientific literacy. This quantitative study was conducted with natural sciences and technology, natural sciences, and mathematics teachers, and data was analysed using SPSS 27. The results showed a statistically significant relationship between inquiry-based approaches and learners' acquisition of science process skills. Although teachers understood the advantages of using inquiry-based teaching, there were many obstructions to the implementation of this in classrooms in the schools used in this study.

Keywords: Basic science process skills, inquiry-based approaches, inquiry-based science education, integrated science process skills, science process skills

Introduction

The broader view of science challenges learners to inquire about their world and develop certain intellectual skills using specialized methods for scientific investigation. These specialized methods or science process skills (SPS) are explained as competencies and investigative skills used by scientists (Celik, 2022; van Rooyen & de Beer, 2006). SPS are regarded as important skills that afford learners an opportunity to interact with their environment and be able to intelligently manipulate it (Inayah et al., 2020). The traditional way of teaching natural sciences (NS) and natural sciences technology (NST) leads to a loss of interest in science among learners and consequently to low scientific literacy and there is a growing need for the teaching of science in early childhood development (Pakombwele & Tsakeni, 2022). Similarly, Makgato and Mji (2006) note that teaching methods that do not engage learners, result in poor learner attainment in the subject. The teacher must therefore create a platform for learners to ask their own investigable questions and research their ideas so that effective learning can take place. This is an inquiry-based approach and employs classroom practices, such as observing, generating questions and solving problems (Gholam, 2019; Mayer & Alexander, 2011). Majeed et al. (2023) and Veloo et al. (2013) found that using an inquiry-based teaching approach can result in improvement in learners' attainment in science, attitude to science, critical thinking skills, and science process skills.

Consequently, science process skills have been a key focus of research for many years globally, and in South Africa (Dourado & Leite, 2013; Molefe & Aubin, 2021; Osborne et al., 2003; Tobin & Tippins, 2012; Wellington, 1989). South Africa's National Curriculum Statement (NCS) seeks to produce learners who are observant, problem-solvers, and can make decisions using their critical thinking skills and who think for themselves by applying the acquired knowledge and skills so that they develop into independent learners (DBE 2011; Tagutanazvo & Bhagwandeen, 2022). The need is emphasized for the learners to do research and acquire deeper knowledge and master the content through the skills of observing, measuring, inferring, and manipulating variables. These activities are the process skills that must be developed by teachers and mastered by learners so that their science knowledge can improve. The SPS is applied by many people when they are solving problems and developing new knowledge (Rambuda & Fraser, 2004). A study conducted by Simsek and Kabapinar (2010) on the positive impact of the inquiry-based teaching method indicates improvement in the learners' understanding of concepts and in their SPS.

The current research attempted to address the following questions:

- How do teachers use inquiry-based science education (IBSE) to develop primary school learners' science process skills?

- Which science process skills (SPS) do primary school learners learn when inquiry-based science education (IBSE) is used in the classroom?
- What are the obstruction factors that affect the teachers from implementing IBSE in developing the learners' SPS?

Theoretical Framework

There are several theories that can be used to address different ways of teaching and learning. Constructivism, an approach through which learners use their existing experiences to construct new knowledge (Bada, 2015; Burhanuddin et al., 2021) was the theory used by the researcher to address this research problem. Bada (2015) emphasizes that one of the requirements of education is that learners be active participants in the learning process rather than teachers assuming that they can transfer knowledge to passive learners. According to Constructivism, the primary aim of teaching is to assist learners to acquire skills and to build new knowledge and understanding rather than acquiring scientific head knowledge (Simsek & Kabapinar, 2010, as cited in Llewellyn, 2013). Constructivism involves a learning process which is enables learners to build on previous knowledge and understanding to actively construct new learning. The inquiry-based approach is usually linked to the constructivist perspective on acquiring knowledge because there is active interaction between the teacher and the learner in the classroom (Mayer & Alexander, 2011).

An inquiry-based science education (IBSE) approach is a learner-centred and teacher-guided teaching strategy that engages learners in investigating real-world questions that they choose within their context (Beichumila et al., 2022; Tairab & Al-Naqbi, 2018). It is characterised by the amount of responsibility learners have in posing and responding to questions, designing investigations, and evaluating and communicating their results (Harlen, 1999). Chebii et al. (2012) contends that successful science teaching requires that innovative teaching strategies be employed. Dokme and Aydinli (2009), and Majeed et al. (2023) point out that using an inquiry-based strategy helps develop learners' SPS, critical thinking and scientific reasoning skills. Edelson et al. (1999) argue that through an inquiry-based approach, learners enhance habits of mind that can last a lifetime and guide learning and creative thinking. Biswal and Behera (2023), Fraser-Abder (2011) and Rambuda and Fraser (2004) emphasise that inquiry-based approach is important for enhancing SPS.

The application of an inquiry-based approach in the science classroom may enhance innovation, critical thinking, mastery of content and subject performance (Crawford, 2007; Ekici & Erdem, 2020). This is confirmed by Ross et al. (2004) who assert that learning becomes more permanent, meaningful, and exciting when learners themselves take ownership of learning process and engage in high order thinking tasks.

SPS are skills that scientists apply as they engage in various types of scientific inquiry such as asking questions, observing, formulating hypotheses, interpreting data and communicating results (Ambross, 2011; Ekici & Erdem, 2020).). Yamtinah et al. (2017) state that learning science through the inquiry-based approach, and the enhancement of SPS are interrelated and enable learners to understand the concepts and improve the active participation and leading role in their learning. SPS are categorized into two different types, i.e. basic SPS and integrated SPS. Basic SPS can be emphasised at the primary grades and then serve as a foundation for using integrated skills at higher grades (Gizaw & Sota, 2023; Martin et al., 2005; Widyaningsih et al., 2020). Indri et al. (2020) and Keil et al. (2009) state that SPS cannot be separated from the day-to-day learning of science, both in the classroom and in many areas of life. Harlen (1999) avers that while a comprehensive mastering of science content may be a challenge, the mastering of SPS enables learners to have a deeper understanding of the concepts that they acquire and equips them with the skills of acquiring knowledge of new content. Basic SPS are simple skills used by learners when they perform science in the classroom (Gizaw & Sota, 2023; Rezba et al.,1995). The basic SPS include six common everyday skills, namely observation, classification, measurement, prediction, inference, and communication (McMillan, 2007). As the learners develop mastery of these skills, fair testing and other integrated process skills should be introduced (Goldston & Downey, 2013). Gizaw and Sota (2023) and Padilla (1990) conclude that basic skills can be developed and that when they are developed well, they can be readily applied to new situations.

Integrated science process skills are more complex and require a combination of several basic skills to perform a process (Gizaw & Sota, 2023; van Rooyen & de Beer, 2006). They build on the basic process skills and are associated with experimentation. These include controlling variables, defining variables operationally, formulating a hypothesis, interpreting data, experimenting, and formulating models (Gizaw & Sota, 2023; Martin et al., 2005). Learning of these skills empowers learners to answer and pose many of their own questions. When learners develop integrated skills, they are able to interpret what they observe and design investigations to test their ideas (Gizaw & Sota, 2023; Rezba et al., 1995).

Methodology

This study employed a quantitative approach that entailed analysis of data on teachers obtained from a questionnaire. The distribution of one hundred and fifty questionnaires was done after the researchers were granted permission to conduct the study by the Central University of Technology, Free State, Free State Department of Education, and the school principals. The questionnaire consisted of four parts, that is, Part A which covered demographic information; Part B with sixteen items which elicited teachers' thoughts on the application of the inquiry-based approaches; Part C with thirty-five items was based on science process skills and Part D with eight items which elicited responses was about the obstruction factors (see Appendix A). The items on Parts B, C and D had to be answered on a seven-point semantic differential scale. Out of one hundred and fifty (150) questionnaires that were distributed, one hundred and twenty-five (125) were fully completed and returned.

The study employed purposive sampling because not all schools possessed the required characteristics. For instance, some did not have laboratories and science kits. The first author selected the individuals that could possibly give more information pertaining to the research topic. The respondents were assured that their names and information would not be disclosed to anyone.

Descriptive and inferential statistics were employed to analyze the quantitative data obtained. Methods of data analysis used were measures of central tendency, namely, the mean and the median as well as a measure of dispersion, namely, standard deviation (Springer, 2010). The parametric techniques that were employed for analyzing data are as follows:

- Pearson product-moment correlation coefficient
- An independent-samples t-test
- One-way between groups ANOVA.

The pilot study was subjected to the reliability and validity of measurement scale. Reliability was determined through the reliability coefficient, Cronbach's alpha. The Cronbach's alpha value was 0.93, suggesting an excellent internal consistency reliability of the scale.

Furthermore, all items which loaded below 0.05 were removed from the questionnaire. The necessary amendments were made and thereafter the final questionnaire was compiled.

Results

A principal component analysis was used to assess the underlying structure for seventy-three (73) items on the questionnaire that was developed for the research using Varimax. The Kaiser-Myer Olk (KMO) and Bartlett's Test of Sphericity were used to verify the sampling adequacy of the factor analysis. As mentioned by Pallant (2013), for the factor analysis to be considered appropriate, Kaiser's recommendation is accepting values greater than 0.6 and Bartlett's Test of Sphericity value is significant when the value is 0.5 or smaller. The following table shows the KMO and Bartlett's Test of Sphericity.

Table 1: *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,858
Bartlett's Test of Sphericity	Approx. Chi-Square	5905,227
	df	1711
	Sig.	0,000

In this research, the KMO value is 0.86, which is above 0.6 therefore it can be concluded that the sample size of the research is adequate for the factor analysis. Bartlett's Test of Sphericity is significant at $p=0.00$ which is smaller than 0.5, indicating that the correlations between items are highly significant ($p < 0.5$), this implies factor 108 analysis is appropriate.

Table 2: *Descriptive Statistics of Factors* (n=125)

Questionnaire Subscales	**Mean**	**Median**	**Standard Deviation**	**Cronbach's alpha**
V74r. inquiry-based Approach	5.82	5.93	0.18	0.90
V75r. SPS	5.03	5.43	0.86	0.94
V76r. Obstruction factors	5.19	5.13	1.07	0.51

Analysis of data in Table 2 shows that the inquiry-based approach and SPS have Cronbach alpha values of above 0.9, which suggests that the two factors have high internal consistency reliability. Pallant (2013) states the difficulties in deciding on which numbers to retain when a small scale is used. In this research, Factor 1 has 16 items, Factor 2 has 21 items, and Factor 3 has eight items. The mean score is high in the inquiry-based approach (*M*=5.82, *MD*=5.93, *SD*=0.18). The mean reveals that the inquiry-based teaching approach is strongly implemented. This is followed by the obstructing factors (*M*=5.19; *MD*=5.13; *SD*=1.07). The mean for the obstruction factors reveals that obstruction factors frequently impact the application of the IBSE approach. It is interesting to note that SPS has the lowest mean value. Although the mean is low, SPS are also strongly developed in learners (*M*=5.03, *MD*=5.43, *SD*=0.86). As Keil et al. (2009) argue learners need to improve SPS for success in science and in their everyday experiences. The inquiry-based approach and SPS have mean values which are lower than the median values, which results in the negative skewness of the graph. The implication is that participants' scores are at the lower end of the distribution and strongly develop IBSE and SPS. In obstruction factors, the mean is higher than the median, which results in positive skewness of the graph. This implies the participants' scores are at the higher end of the distribution and agree on obstruction factors that strongly impact the application of IBSE.

Table 3: ***Inquiry-based Approach*** (n=125)

Statement: V15-V30	*M*	*MD*	*SD*
V15. I ask questions requiring learners to give their ideas.	5.46	6.00	1.17
V16. I provide materials and equipment that are appropriate for the activities and age of learners	5.45	6.00	1.17
V17. Learners have access to secondary sources of information such as textbooks and posters	5.20	5.00	1.44
V18. Classroom space is arranged so that learners can work in well-organised groups	4.91	5.00	1.63

V19. The lesson is planned to allow discussing learners' ideas	5.56	6.00	1.19
V20. The lesson is organised to give enough time to clarify the question being investigated	5.48	6.00	1.13
V21. I encourage learners to ask investigable questions and problems for activities	5.58	6.00	1.00
V22. I design lessons that give enough time to collect data	5.56	6.00	1.09
V23. The lessons are designed to give time to discuss what has been done and found.	5.44	6.00	1.13
V24. Learners are taught techniques for using equipment including measuring instruments safely and effectively	5.46	6.00	1.21
V25. The learners are helped to use appropriate scientific terms and representations	5.49	6.00	1.04
V26. Tolerance and mutual respect in class and discussions are encouraged	5.93	6.00	1.09
V27. Learners' work is displayed in the classroom	5.06	5.00	1.47
V28. I help learners to keep notes and record results systematically	5.45	6.00	1.23
V29. I involve learners in planning investigations	5.43	6.00	1.14
V30. I design lessons that effectively involve learners	5.88	6.00	1.05

Analysis of data in Table 3 indicates that the teachers encourage tolerance and mutual respect and discussions in the classroom (*M*=5.93, *MD*=6.00, *SD*=1.09), the teachers design lessons that effectively involve learners (*M*=5.88, *MD*=6.00, *SD*=1.05) and teachers encourage learners to ask investigable questions with problems for activities (*M*=5.58; *MD*= 6.00; *SD*=1.00). The classroom space is modestly arranged for learners to work in groups (*M*=4.91; *MD*=5.00, *SD*=1.63), learners' work is displayed in the classroom (*M*=5.06, *MD*=5.00, *SD*=1.47) and learners have access to secondary sources of information such as textbooks and posters (*M*= 5.20; *MD*=5.00; *SD*=1.44).

Table 4: *Basic Science Process Skills* (n=125)

Statement: V31-V51, Learners:	*M*	*MD*	*SD*
V31. Identify the properties of objects such as colour, size and shape	5.75	6.00	1.05
V32. State noticeable changes in objects or events	5.45	5.00	1.11
V33. State noticeable similarities and differences in objects or events	5.58	6.00	1.10
V34. Arrange objects in sequence by length, weight chronologically and numerically	5.47	6.00	1.24
V35. Use standard tools such as the meter stick, ruler and scale to find the quantity	5.48	6.00	1.38
V36. Describe objects or events	5.43	6.00	1.25
V37. Make charts, tables and graphs (represent data) to show their findings	5.49	6.00	1.39
V38. Record data as needed to keep trace of their findings	5.31	5.00	1.29
V39. Construct exhibits and make models	5.22	5.00	1.34
V40. Classify objects or events in order by some properties or value	5.26	5.00	1.34
V41. Think systematically and logically about what might happen next	5.22	5.00	1.36
V42. Explain an observation	4.85	5.00	1.21
V43. Are curious to do an investigation	4.80	5.00	1.11

Statement: V31-V51, Learners:	*M*	*MD*	*SD*
V44. Explain observations or relationships in terms of some principles or concepts	5.10	5.00	1.19
V45. Apply concepts or knowledge gained in one situation to solve the problem	4.82	5.00	1.14
V46. Understand that there can be more than one possible explanation of an event	4.80	5.00	1.19
V47. Realise the need to test explanation by gathering information	4.74	5.00	1.16
V48. Identify trends or relationships	4.72	5.00	1.20
V49. Draw conclusions	4.67	5.00	1.22
V50. Put various pieces of information together and infer something from them	4.73	5.00	2.21
V51. Use patterns or relationships in information, measurements or observations to make predictions	4.86	5.00	1.17

Analysis of data in Table 4 shows the basic science process skills that are developed and also reveals that learners identify properties of objects such as colour, size, and shape (*M*=5.75, *MD*=6.00, *SD*=1.05), the learners state noticeable similarities and differences in objects or events (*M*=5.58, *MD*=6.00, *SD*=1.10), the results further show that learners make charts, tables, and graphs (represent data) to show their findings (*M*=5.49, *MD*=6.00, *SD*=1.39). The learners modestly draw conclusions (*M*=4.67; *MD*=5.00; *SD*=1.22), modestly identify trends or relationships (*M*=4.72; *MD*=5.00; *SD*=1.20) and learners modestly put various pieces of information together and infer something from them (*M*=4.73; *MD*=5.00; *SD*=2.21).

Table 5: *Integrated Science Process Skills* (n=125)

Statement V52-V65, Learners:	*M*	*MD*	*SD*
V52. Realise the differences between a conclusion that fits all the evidence and inference that goes beyond it	4.70	5.00	1.22

V53. Check possible relationships with evidence	5.25	5.00	1.51
V54. Manipulate materials practically to investigate	4.91	5.00	1.24
V55. Identify controlled variables	4.77	5.00	1.18
V56. Identify unchanged variables	4.75	5.00	1.19
V57. Identify what is to change or be changed	4.89	5.00	1.21
V58. Use materials and scientific concepts to investigate problems	5.00	5.00	1.08
V59. Decide how to collect and record relevant data	4.89	5.00	1.21
V60. Decide on the equipment and materials to be used to conduct an investigation	4.82	5.00	1.22
V61. Identify what variables are to be kept the same for a fair test	4.87	5.00	1.20
V62. Identify what to be measured	4.86	5.00	1.23
V63. Decide the order of the steps in doing the investigation	4.98	5.00	1.21
V64. Make a record of what they did and found	5.23	5.00	1.12
V65. Design an investigation to test a given hypothesis	4.98	5.00	1.28

Analysis of data in Table 5 shows that learners check possible relationships with evidence (*M*=5.25; *MD*=5.00; *SD*=1.51), learners also make a record of what they did and found (*M*=5.23; *MD*=5.00; *SD*=1.12) and they use materials and scientific concepts to investigate problems (*M*=5.01, *MD*=5.00, *SD*=1.08). Table 6 also shows that, according to the teachers, learners modestly realise the difference between a conclusion that fits all the evidence and inference that goes beyond it (*M*=4.70; *MD*=5.00; *SD*=1.22), learners modestly identify unchanged variables (*M*=4.75; *MD*=5.00; *SD*=1.20) and they modestly identify controlled variables (*M*=4.77; *MD*=5.00; *SD*=1.8).

Table 6: *Obstruction Factors* (n=125)

Statement	*M*	*MD*	*SD*
V66.Teacher workload	5.29	6.00	1.72
V67.Time allocated to the subject	4.96	5.00	1.71
V68.Poor learner science background	5.01	5.00	1.56
V69.Pressure to cover curriculum	5.84	6.00	1.36
V70.Learner language barrier	6.02	6.00	4.72
V71.Lack of resources	5.20	5.00	1.44
V72.Insufficient in-service training	4.91	5.00	1.53
V73.Teacher's lack of subject knowledge	4.18	5.00	1.89

Analysis of data in Table 6 shows that learners usually have language barrier(s) (*M*=6.02; *MD*=6.00; *SD*=4.72). Responses indicate that learner language is the most obstructive factor in implementing IBSE approach. Pressure to cover curriculum, (*M*=5.84; *MD*=6.00; *SD*=1.36) and teacher workload (*M*=5.29, *MD*=6.00, *SD*=1.72) strongly obstruct the application of IBSE approach. Teacher's lack of subject knowledge (*M*=4.18; *MD*=5.00; *SD*=1.89, insufficient in-service training (*M*=4.91, *MD*=5.00, *SD*=1.53) and time allocated to the subject (*M*=4.96; *MD*=5.00; *SD*=1.71) moderately obstruct the application of IBSE approach.

Table 7: *Pearson Correlation Coefficient* (n=125)

Correlations		V74r. inquiry-based Approach	V75r. SPS
V74r. Inquiry-based Approach	Pearson Correlation	1	.545*
	Sig. (2-tailed)		.000

	N	125	125
V75r. SPS	Pearson Correlation	.545*	1
	Sig. (2-tailed)	.000	
	N	125	125

Note. *Correlation is significant at the 0.01 level (2-tailed).

Analysis of data in Table 7 indicates statistically significance relationship between inquiry-based approaches and SPS, with Pearson correlation (r=0.55) indicating a positive relationship between the inquiry-based science approach and SPS. The strength of the relationship is high because the value of r is 0.55.

Table 8: *T-test Comparison of Male and Female Teachers on Inquiry-based Science Education, Science Process Skills and Obstruction Factors* (n=125)

Variable		*M*	*SD*	*t*	*df*	*p*	*d*
IBSE				0.71	123	0.477	0.004
	Males	88.19	12.22				
	Females	86.63	12.16				
SPS				0.55	123	0.580	0.002
	Males	177.79	32.02440				
	Females	174.79	28.36203				
Obstruction Factors				0.71	123	0.482	0.004
	Males	42.0877	9.53992				
	Females	41.0000	7.71701				

Analysis of data in Table 8 reveals no statistically significant difference between gender and IBSE since the p-value (0.48) is greater than 0.05 ($p > 0.05$). Furthermore, the mean for males is (M=88.19) and for females is (M=86.63). The difference between the means is 1.56 and the effect size, *d*, is approximately 0.00. Based on the above results, the null hypothesis is accepted, which states, there is no statistically significant difference between male and female teachers in the application of inquiry-based approaches when teaching NS. The results from Table 8 also show no statistical difference between the two genders in the application of SPS when teaching NS, since the p-value (0.58) is greater than 0.05 ($p > 0.05$). The examination of the two groups' means indicates that the average score for males is (*M*=177.79) and for female teachers is (*M*=174.79). The difference between the means is 3.0 and the effect size, *d*, is 0.00. Table 8 shows that there is no statistical difference between the two genders regarding obstructing factors in the teaching of NS since the *p*-value (0.48) is greater than 0.05 ($p > 0.05$). Moreover, the examination of the two groups' means indicates that the average score for males is (*M*=42.09) and for female teachers is (*M*=41.00). The difference between the means is 1.09 and the effect size, *d*, is again 0.00.

Table 9: *Means and Standard Deviations Comparing Three Age Groups on the Inquiry-based Approach, Science Process Skills and Obstruction Factors* (n=125)

Age Groups	Inquiry-based Approach			Science Process Skills		Obstruction Factors	
	n	*M*	*SD*	*M*	*SD*	*M*	*SD*
22-35 years	34	89.00	9.80	176.24	25.40	41.24	11.06
36-45 years	35	85.34	13.83	176.86	30.14	40.71	7.47
46-59 years	56	87.59	12.37	175.68	32.86	42.14	7.56

Table 10: *One-way Analysis of Variance Summary Table Comparing Three Age Groups on the Inquiry-based Approach, Science Process Skills and Obstruction Factors*
n=125)

Source	*df*	*SS*	*MS*	*F*	*p*	*Eta squared*
IBSE						
Between groups	2	236.77	118.38	0.80	0.45	0.01

Within groups	122	18097.44	148.34			
Total	124	18334.21				
SPS						
Between groups	2	30.18	15.09	0.02	0.98	0.00
Within groups	122	111574.62	914.55			
Total	124	111604.80				
Obstruction factors						
Between groups	2	47.13	23.57	0.32	0.73	0.01
Within groups	122	9076.12	74.39			
Total	124	9123.25				

Analysis of data in Tables 9 and 10 shows that a statistically significant difference was not found among the three age groups on IBSE, SPS and obstructing factors, since the *p*-values were all above 0.05 ($p > 0.05$). IBSE was (F=0.80; p=0.45). For SPS, results showed (F=0.02; p=0.98) and on obstruction factors (F=0.32; p=0.73). Table 9 shows that the mean for IBSE is (M=89.00) for teachers whose age group is 22-35 years, (M=85.34) for teachers whose age group is 36-45 years, and (M=87.59) for teachers whose age group is 46-59 years. The SPS mean is (M=176.24) for teachers whose group age is 22-35 years, (M=176.86) for teachers whose age group is 36-45 years, and (M=175.68) for teachers whose age group is 46-59 years. Lastly, the table shows that the mean for obstruction factors is (M=41.24) for the age group of 22-35 years, (M=40.71) for teachers whose age group is 36-45 years and (M=42.14) for teachers whose age group is 46-59 years.

Table 11: *Means and Standard deviations Comparing Three Groups of Experience Teaching NS in Years on the Inquiry-based Approach, Science Process Skills and Obstruction Factors*

(n = 125)

Experience teaching NS in years	Inquiry-based Approach	Science Process Skills	Obstruction Factors

	n	*M*	*SD*	*M*	*SD*	*M*	*SD*
1-10 years	88	86.69	11.81	173.99	29.20	41.70	9.45
11-20 years	27	86.93	13.41	175.96	29.75	41.59	6.28
21-30 years	10	94.20	10.60	195.80	33.58	39.40	5.54

Table 12: *One-way Analysis of Variance Summary Table Comparing Groups of Experience Teaching NS on Inquiry-based Approach, Science Process Skills and Obstruction Factors* (n = 125)

Source	*df*	*SS*	*MS*	*F*	*p*	*Eta squared*
IBSE						
Between groups	2	512.04	256.02	1.75	0.18	0.03
Within groups	122	17822.17	146.08			
Total	124	18334.21				
SPS						
Between groups	2	4273.25	2136.62	2.43	0.09	0.04
Within groups	122	107331.55	879.77			
Total	124	111604.80				
Obstruction factors						
Between groups	2	48.01	24.01	0.32	0.73	0.01
Within groups	122	9075.24	74.39			
Total	124	9123.25				

Table 13: *Means and Standard Deviations Comparing Three Subjects Taught using Inquiry-based Approach, Science Process Skills and Obstruction Factors* (n=125)

Subject Taught	Inquiry-based Approach			SPS		Obstruction Factors	
	n	*M*	*SD*	*M*	*SD*	*M*	*SD*
NST	54	88.28	11.77	177.17	28.80	40.57	7.09
Mathematics	24	86.79	12.45	173.04	26.57	43.25	7.96
NS and Mathematics	47	86.55	12.64	176.60	33.34	41.66	10.30

Table 14: *One-way Analysis of Variance Summary Table Comparing Groups of Taught subjects on Inquiry-based Approach, Science Process Skills and Obstruction Factors* (n=125)

Source	*df*	*SS*	*MS*	*F*	*p*	*Eta squared*
IBSE						
Between groups	2	83.80	41.90	0.28	0.76	0.01
Within groups	122	18250.41	149.59			
Total	124	18334.21				
SPS						
Between groups	2	297.02	148.51	0.16	0.85	0.00
Within groups	122	111307.78	912.36			
Total	124	111604.80				
Obstruction factors						
Between groups	2	120.99	60.50	0.82	0.44	0.01
Within groups	122	9002.26	73.79			
Total	124	9123.25				

Analysis of data in Tables 13 and 14 also show no statistically significant differences amongst groups of taught subjects and the three factors, since the *p*-values for all are above 0.05 ($p > 0.05$). IBSE had (F=0.28; p=0.76). SPS had (F=0.16; p=0.85) and obstruction factors resulted in (F=0.82; p=0.44). Table 13 shows that the IBSE mean is (M=88.28) for teachers who teach NST; (M=86.79) for teachers who teach mathematics, and (M=86.55) for teachers who teach NS and mathematics. The SPS mean is (M=177.17) for teachers who teach NST; (M=173.04) for teachers who teach mathematics, and (M=176.60) for teachers who NS and mathematics. Lastly, the table shows that the mean for obstruction factors is (M=40.57) for teachers who teach NST; (M=43.25) for teachers who teach mathematics; and (M=41.66) for teachers who teach NS and mathematics. Put differently, teachers who teach different subjects are not statistically significant in their views regarding the three factors.

Conclusions and Recommendations

The findings of the study show that teachers apply different inquiry-based approaches in their classrooms depending on the content to be taught and the learning objectives to be attained. The teachers know the positive impact the inquiry-based approaches have on learner performance and on the development of SPS. Gizaw and Sota (2023) argue that instructional strategies for enhancing SPS are student-centred as teachers can engage students in minds-on and hands-on activities. Data generated from the questionnaires indicate that the teachers agree that inquiry-based approaches develop creative thinking, problem-solving, and question-asking skills. Teachers design lessons that effectively allow learners to be active participants during the learning process. The participants also pose high-order questions that require critical and creative thinking. These results, therefore, support the findings of researchers such as Ambross (2011) Ekici and Erdem, (2020) Ramnarain (2014), and Simsek and Kabapinar (2010). The results also reveal that the teachers do teach and develop the SPS as they know that when the skills are well learned, they can be applied to new and different situations. This finding supports the findings of Padilla (1990) and Gizaw and Sota (2023), Rambuda and Fraser (2004) and Widyaningsih et al. (2020). The results indicate that basic SPS are better taught and developed than integrated SPS. The data generated from the teachers also indicate that although the teachers implement the inquiry-based science approach to develop the learners' SPS, there are, however, some factors that obstruct them from implementing the inquiry-based teaching and learning approaches. The teachers indicate impediments such as learner language barrier, pressure to cover curriculum, heavy teacher workload, lack of resources, poor learner science background, insufficient time allocated to the subject, insufficient in-service training, and teachers' lack of subject knowledge. The findings on the impediments are in line with those of Ramnarain, 2014, Tairab & Al-Naqbi, 2018, Wakoli, 2016. These obstruction factors impact the effective and efficient implementation of the inquiry-based approaches in classrooms which means learner's ability to solve problems by using critical thinking is not used as required by the National Curriculum Statement.

The results also indicate that there is no statistical significance between biographical variables (such as gender, age, teaching experience and subject taught) and the teacher responses to the following three factors: application of inquiry-based approaches, application of SPS when teaching NS; and to factors which obstruct the teaching of NS. The findings on biographical variables confirm the findings of Tairab and Al-Naqbi (2018).

The challenges that are highlighted by the research findings suggest that there is a need to employ more teachers with subject knowledge. A curriculum review should be done requiring that only fundamental topics are taught. Schools must be equipped with science materials, necessary equipment and teachers should use and design types of laboratory activities for the students.(Molefe, Stears & Hobden, 2016). The school and the parents could raise funds to buy the resources and create a partnership with local businesses and non-governmental organizations (NGOs). This recommendation is in line with that of Heeralal (2014) who also emphasizes that schools can engage in fundraising programmes that are aimed at buying the resources for doing experiments and investigations. The DBE should provide continual professional training workshops which are aimed at improving pedagogical approaches, science process skills, and science content (Kazeni, 2021).The improvement of teachers' professional qualifications should elicit a continual instead of a once-off bonus. Teachers should be encouraged to belong to professional learning communities (PLCs where good practices are shared. The PLCs are also encouraged by Marsigit (2007) and Ramnarain (2014) who affirm that lesson study activities increase teachers' competence regarding the delivery of teaching, different teaching strategies, and cooperation. It is further recommended that further research should be done on the development of basic SPS, excluding the integrated SPS in primary schools.

Limitations of the research

This research was based in the primary schools in the Thabong township and in a few mine schools in the Lejweleputswa Education District and the participants were made up of 125 Grades 4-7 teachers who teach NST, NS and mathematics. The actual number of participants limited the statistical power for making general findings to a wider community in the district. Thabong township is in Welkom which is a gold mining town. Out of the six schools located in the mining premises, only three teachers participated in this study. Another limitation was that not many different methods of acquiring information were employed, such as the observations and the pre- and post-tests.

On reflection, it is evident that the information-gathering techniques were able to provide information for answering the research questions; however, there is a need for more information around development of SPS through the IBSE approach. Further research can also focus on using classroom observations and using the pre-test and post-tests to gain more insight and a bigger picture.

Conflict of Interest

This study was derived from a Master of Education dissertation submitted by the first author and supervised by the second author.

Author Contribution

S. Moopeloa contributed concept, data collections and interpretation and the initial draft of the manuscript. R. Bhagwandeen contributed the theoretical framework, Ethics Clearance, securing funding, and was the main supervisor of the master's dissertation on which this paper was based. He did the revision of the draft article; and A. M. Rambuda was responsible for the statistical analysis in the study.

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APPENDIX A

QUESTIONNAIRE

- Please complete the questionnaire anonymously.
- No one is pressurized to complete the questionnaire.
- Participation is voluntarily and sincerely appreciated.
- Information will be treated as confidential, and no one will be identified.
- You are encouraged to leave NO question unanswered.
-

PART A: Biographical Information

1. What is your gender?

Male	1
Female	2

2. What is your race?

Black	1
Coloured	2
White	3

3. What subject(s) do you teach?

Natural Sciences/Technology	1
Mathematics	2
Natural Sciences and Mathematics	3

4. Write the total years of your teaching experience.

5. How many years have you taught Natural Sciences?

6. Grade teaching presently

4	1
5	2
6	3
7	4
More than one grade	5

7. Indicate your age in the box provided below.

8. What is your Professional Qualification?

PTC	1
SPTD	2
STD	3
BAED	4
PGCE	5

9. What were your Major subjects?

Science and Mathematics	1
Biology and Mathematics	2
Biology	3
Others	4

10. What is your highest Academic Qualifications?

ACE	1
Diploma	2
Degree	3
Diploma and Degree	4

11. Indicate in the box provided below period of training in days offered to you by the Department of Basic

Education (DBE) to Implement the new curriculum.

12. How do you rate the quality of training?

Excellent	1
Very Good	2
Good	3
Fair	4
Poor	5

13. How many learners do you teach in one class? Write the number in the box provided.

14. How do you classify your school?

Town	1
Township	2
Mine	3
Farm	4

Part B: Inquiry-Based Approach

Indicate the degree to which you do as described in the statement.

Please respond by making a cross(X) over the number in the appropriate block.

USE THE KEY BELOW

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

	Statement								Office use only
15.	I ask questions requiring learners to give their ideas.	1	2	3	4	5	6	7	
16.	I provide materials and equipment that are appropriate for the activities and age of learners	1	2	3	4	5	6	7	
17.	Learners have access to secondary sources of information such as textbooks and posters	1	2	3	4	5	6	7	
18.	Classroom space is arranged so that learners can work in well organized groups	1	2	3	4	5	6	7	
19.	The lesson is planned to allow discussing learners' ideas	1	2	3	4	5	6	7	
20.	The lesson is organized to give enough time to clarify the question being investigated	1	2	3	4	5	6	7	
21.	I encourage learners to ask investigable questions and problems for activities	1	2	3	4	5	6	7	
22.	I design lessons that give enough time to collect data	1	2	3	4	5	6	7	
23.	The lessons are designed to give time to discuss what has been done and found.	1	2	3	4	5	6	7	

	Statement								Office use only
24.	Learners are taught techniques for using equipment including measuring instruments safely and effectively	1	2	3	4	5	6	7	
25.	The learners are helped to use appropriate scientific terms and representations	1	2	3	4	5	6	7	
26.	Tolerance and mutual respect in class and discussions are encouraged	1	2	3	4	5	6	7	
27.	Learners’ work is displayed in the classroom	1	2	3	4	5	6	7	
28.	I help learners to keep notes and record results systematically	1	2	3	4	5	6	7	
29.	I involve learners in planning investigations	1	2	3	4	5	6	7	
30.	I design lessons that effectively involve learners	1	2	3	4	5	6	7	

PART C: Science Process Skills (Basic and Integrated Skills)

USE THE KEY BELOW

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

31.	Learners identify the properties of objects such as colour, size and shape	1	2	3	4	5	6	7	
32.	Learners state noticeable changes in objects or events	1	2	3	4	5	6	7	

33.	Learners state noticeable similarities and differences in objects or events	1	2	3	4	5	6	7	
34.	Learners arrange objects in sequence by length, weight chronologically and numerically	1	2	3	4	5	6	7	
35.	Learners use standard tools such as the meter stick, ruler and scale to find quantity	1	2	3	4	5	6	7	
36.	Learners describe objects or events	1	2	3	4	5	6	7	
37.	Learners make charts, tables and graphs (represent data) to show their findings	1	2	3	4	5	6	7	
38.	Learners record data as needed to keep trace of their findings	1	2	3	4	5	6	7	
39.	Learners construct exhibits and make models	1	2	3	4	5	6	7	
40.	Learners classify objects or events in order by some properties or value	1	2	3	4	5	6	7	
41.	Learners think systematically and logically about what might happen next	1	2	3	4	5	6	7	
42.	Learners explain an observation	1	2	3	4	5	6	7	
43.	Learners are curious to do investigation	1	2	3	4	5	6	7	
44.	Learners explain observations or relationships in terms of some principles or concepts	1	2	3	4	5	6	7	
45.	Learners apply concepts or knowledge gained in one situation to solve problem	1	2	3	4	5	6	7	
46.	Learners understand that there can be more than one possible explanation of an event	1	2	3	4	5	6	7	
47.	Learners realize the need to test explanation by gathering information	1	2	3	4	5	6	7	
48.	Learners identify trends or relationships	1	2	3	4	5	6	7	
49.	Learners draw conclusions	1	2	3	4	5	6	7	

50.	Learners put various pieces of information together and infer something from them	1	2	3	4	5	6	7	
51.	Learners use patterns or relationships in information, measurements or observations to make predictions	1	2	3	4	5	6	7	

52.	Learners realize the differences between a conclusion that fit all the evidence and inference that goes beyond it	1	2	3	4	5	6	7	
53.	Learners check possible relationships with evidence	1	2	3	4	5	6	7	
54.	Learners manipulate materials practically to investigate	1	2	3	4	5	6	7	
55.	Learners identify controlled variables	1	2	3	4	5	6	7	
56.	Learners identify unchanged variables	1	2	3	4	5	6	7	
57.	Learners identify what is to change or be changed	1	2	3	4	5	6	7	
58.	Learners use materials and scientific concepts to investigate problems	1	2	3	4	5	6	7	
59.	Learners decide how to collect and record relevant data	1	2	3	4	5	6	7	
60.	Learners decide on the equipment and materials to be used to conduct an investigation	1	2	3	4	5	6	7	
61.	Learners identify what variables are to be kept the same for a fair test	1	2	3	4	5	6	7	
62.	Learners identify what to be measured	1	2	3	4	5	6	7	
63.	Learners decide the order of the steps in doing the investigation	1	2	3	4	5	6	7	

64.	Learners make record of what they did and found	1	2	3	4	5	6	7	
65.	Learners design an investigation to test a given hypothesis	1	2	3	4	5	6	7	

USE THE KEY BELOW

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

<u>PART D: The following factors hamper my ability to use inquiry approach to teach Science Process Skills effectively.</u> (Obstruction factors) Make a cross (x) in the appropriate block.

USE THE KEY BELOW

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

66.	Teacher workload	1	2	3	4	5	6	7	
67.	Time allocated to the subject	1	2	3	4	5	6	7	
68.	Poor learner science background	1	2	3	4	5	6	7	
69.	Pressure to cover curriculum	1	2	3	4	5	6	7	
70.	Learner language barrier	1	2	3	4	5	6	7	
71.	Lack of resources	1	2	3	4	5	6	7	
72.	Insufficient in-service training	1	2	3	4	5	6	7	
73.	Teacher's lack of subject knowledge	1	2	3	4	5	6	7	