Art. # 1279, 12 pages, doi: 10.15700/saje.v36n3a1279

Exploring student teachers' views of science process skills in their initial teacher education programmes

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The South African secondary school curriculum emphasises the importance of science process skills in its respective natural sciences curricula. The purpose of this study was to explore the views of student teachers with regard to the importance they attach to these skills. A 14-item questionnaire was administered to 75 third- and fourth-year student teachers registered for a Bachelor of Education degree. A small qualitative component was included with a view to identifying selected skills embedded in practical activities the students found interesting. Statistical analysis of the students' responses to the questionnaire items revealed that they rated most skills as important for student teachers to acquire in their teacher education programmes. When asked to identify most important and least important skills for them to acquire personally, the findings were slightly different. With regard to analysis of the students' responses to practical activities, student teachers found interesting, observing and interpreting emerged as key skills. These findings point to indirect influence of their teacher educators' praxis, hence the recommendation to explicitly state the skills included in practical activities offered along with an explanation of how particular skills may be acquired.

Keywords: initial teacher education programmes; practical activities; science process skills; student teachers

Introduction and Background

The South African Department of Basic Education (DBE) places great emphasis on the development of science process skills (SPS) in all science subjects. Science process skills are activities that scientists carry out to acquire information about the world (Aydoğdu, 2015). In the Curriculum and Assessment Policy Statement, the official curriculum policy of the DBE, the sciences curricula discuss all SPS learners are expected to develop (DBE, 2011). In a similar vein, the Department of Higher Education and Training (DHET, 2011) requires all teachers to acquire competence with regard to knowledge, skills and values, which for the science teacher includes SPS. Teachers who demonstrate competence in SPS are important, particularly in emerging economies such as South Africa, because only teachers competent in these skills may be able to provide quality science education, which is the basis for innovation and creativity that drive the economy. It is thus reasonable that teacher educator programmes in South Africa, like teacher education programmes globally, emphasise skills and science education programmes emphasise SPS. While student teachers engage in science for teaching and are not usually regarded as "scientists", there is the view that they need to learn to approach science as scientists do (Coil, Wenderoth, Cunningham & Dirks, 2010). Chabalengula, Mumba and Mbewe (2012) are of the view that student teachers in some institutions in the United States of America show poor understanding of SPS, because their educators do not spend sufficient time teaching these skills.

The research reported here is part of a project on SPS. The first part of the research was a qualitative study (Molefe & Stears, 2014) exploring five teacher educators' views and practice regarding SPS. In the light of our findings regarding the teacher educators' views of SPS, the purpose of this study was to explore the importance student teachers specialising in the various science disciplines attach to SPS, as well as identifying the SPS embedded in practical activities students find most interesting. The questions that guided the research are:

- How do student teachers view selected SPS in terms of their importance for them to acquire in their teacher education programmes?
- How do student teachers enrolled in different science courses view SPS in terms of their importance for them to acquire in those courses?
- What SPS are foregrounded in the practical activities student teachers find most interesting?

Literature Review and Frameworks

The teaching and learning of SPS has been subjected to substantive criticism from various sources (Ault & Dodick, 2010; Harlen, 1999; Kirschner, Sweller & Clark, 2006). While most science education programmes place emphasis on the acquisition of SPS, certain approaches to teaching and learning SPS are questioned. Firstly, there is the view that these skills are not exclusive to science but are general cognitive skills that can be acquired when people engage in ordinary day-to-day activities (Harlen, 1999). Secondly, the rhetoric that content-free process skills acquired in science can be transferred to other disciplines is questioned (Ault & Dodick, 2010). The authors of the current study (Molefe & Stears, 2014) are of the opinion that teaching of skills out of context is not meaningful, as it does not lead to conceptual development. This view is supported by the research of Leggett, Kinnear, Boyce and Bennett (2004), who established that development of skills, knowledge and attitudes should be in tandem with the context in which teaching and learning occurs, both in secondary and tertiary education.

While authors such as Padilla (1990) have long advocated the inclusion of SPS as part of science education, the above criticisms have led to reflection in the science education community as to the nature and purpose of practical work in science. Abrahams and Millar (2008), for instance, emphasise the importance of developing conceptual understanding in science while engaging in practical activities to enhance the development of process skills, rather than using a de-contextualised approach. Molefe and Stears (2014) concur with the opinion that SPS should be contextualised. According to them, SPS should be linked to specific content, and engaged in once conceptual understanding has occurred. In spite of differing views on the relevance of SPS, many researchers still focus on the ways in which SPS are acquired (De Jager & Ferreira, 2003; Koksal & Berberoglu, 2014; Yakar, 2014).

These differing views regarding the nature of SPS have had an impact on teaching and learning (Millar & Driver, 1987; Molefe & Stears, 2014). While there may be consensus that the competencies that students require are framed around skills, knowledge and understanding, as well as attitudes (Woolnough, 1994), the argument also exists that hands-on laboratory activities and high levels of experimentation (Ornstein, 2006) are essential for the development of such competencies. Furthermore, Ornstein (2006) states that the importance attached to the acquisition of SPS is dependent on the importance teachers attach to such SPS. In fact, Coil et al. (2010) argue that science teacher educators' views of SPS and/or lack of a framework in which to work with new content, have a major influence on student teachers' learning of SPS. Thus, their views may determine the way in which the educators facilitate their students' learning of scientific knowledge, and the associated acquisition of practical skills and techniques (Coll & Eames, 2008). Coil et al. (2010) also argue that if SPS are taught in an explicit and scaffolded manner, they should improve students' acquisition and/or development of understanding of science content.

In spite of the emphasis placed on the development of SPS, research has shown that generally, South African learners have misconceptions with regard to these skills (Molefe, 2011) due to a teacher-centred approach, where learners are provided with limited opportunities to engage in various scientific methods that facilitate the development of SPS (Rambuda & Fraser, 2004). Coil et al. (2010) argue that this persists at tertiary level due to the fact that these skills are simply not taught. However, the research of Molefe and Stears (2014) in a particular South African setting shows that SPS are taught, but that conceptual understanding is valued (and thus prioritised) over and above these skills. In view of the emphasis placed on the acquisition of SPS in the national science curricula (DBE, 2011), this research was aimed at finding out how student teachers view SPS, as their perceptions are bound to influence the way they, as future teachers, are likely to approach the teaching of SPS (Abungu, Okere & Wachanga, 2014).

Lortie's (1975) work on the apprenticeship of observation pointed many years ago toward the need for teacher educators to revisit their pedagogies in pre-service science teacher education, including the development of SPS. As referred to earlier, apart from the student teachers' views regarding SPS, another aspect of the present study was based on practical activities. This was important because the goals of practical work in higher education entail development of practical skills and techniques (Coll & Eames, 2008). Furthermore, motivation theories related to science instructional practices (Areepattamannil, Freeman & Klinger, 2011) point to a positive connection between intrinsic motivation (e.g., interest), motivational beliefs, hands-on activities and the associated enhancement of SPS. Thus, if student teachers have positive attitudes towards the practical activities they engage in, this could significantly influence their performance (Ornstein, 2006).

We acknowledge that there are differing views regarding the nature of process skills and particularly SPS. Nevertheless, in order to construct a framework to act as a lens for the study, we were obliged to make choices regarding classification of such skills to enable us to conduct this research. For this purpose we drew on the framework used in the work of Coil et al. (2010) and Leggett et al. (2004) and in the South African national curriculum. The above authors present lists of scientific skills that are distinctly different. There is an overlap in what Coil et al. (2010) call SPS and what Leggett et al. (2004) refer to as generic skills in science. The SPS framework presented below drew on lists compiled by Coil et al. (2010) and stipulated by the South African National Department of Education (DoE, 2002). A range of skills is categorised into two main categories, that is, generic skills and SPS.

While generic skills are skills that may be developed across a number of disciplines, some researchers such as Coil et al. (2010) classify them as SPS. On the other hand, authors such as Harlen (1999) and Millar (1989) support the argument that SPS are more generic than specifically related to science. We concur with Warnich and Meyer (2013) that generic skills and SPS are equally important for teacher education, and it is for that reason that we included both groups of skills, namely, generic skills and SPS. Science process skills are in turn grouped into basic and integrated SPS. Figure 1 illustrates the classification of skills used as a framework to answer the research questions posed in this study.

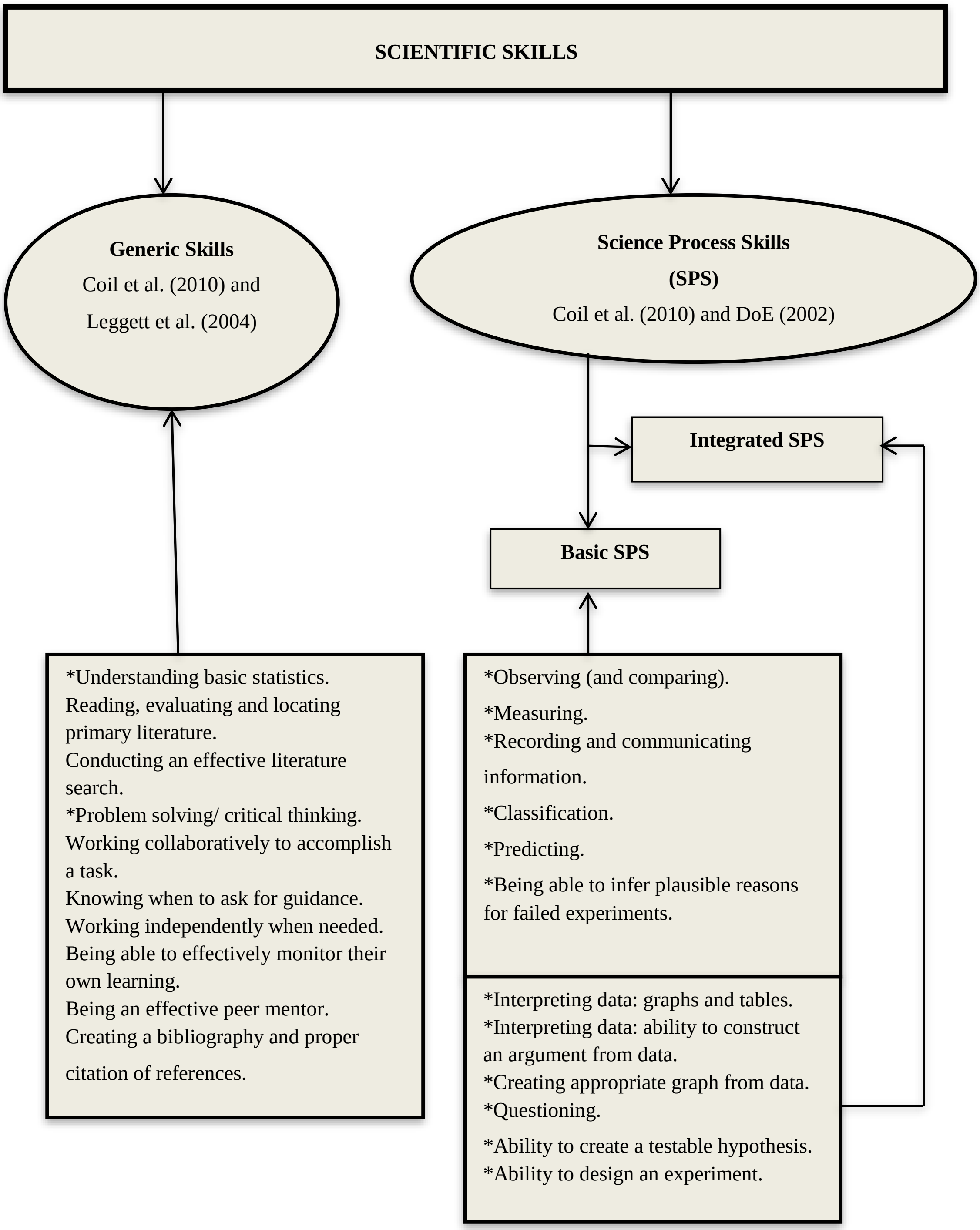

Figure 1 Framework of skills (NOTE: *Skills that were selected for the present study)

In order to establish a connection between practical activities and SPS, we drew on the work of Millar and Abrahams (2009) to provide a framework for linking SPS to the particular objectives of different types of practical work. According to these authors, there are three objectives of practical work. These are: (a) to help students develop their knowledge of the natural world and their understanding of some of the main ideas, theories and models that science uses to explain it; (b) to help students learn how to use some piece(s) of scientific apparatus and/or to follow some standard scientific procedure(s); and (c) to develop students' understanding of the scientific approach to enquiry (e.g., of how to design an investigation, assess and evaluate the data, process the data to draw conclusions, evaluate the confidence with which these can be asserted). Any practical activity should have at least one of the above objectives. Objectives (b) and (c) speak directly to the acquisition of SPS. Table 1 indicates which SPS we linked to each objective.

Table 1 Objectives of practical work and their associated SPS (Adapted from Millar & Abrahams, 2009)

Objectives of practical work	Associated SPS/Generic Skills
To help students learn how to use some piece(s) of scientific apparatus and/or to follow some standard scientific procedure(s).	Observing (and comparing). Measuring. Recording & communicating information. Classification. Interpreting data: graphs and tables. Interpreting data: ability to construct an argument from data. Creating appropriate graph from data. Problem solving/critical thinking. Understanding basic statistics. Questioning.
To develop students' understanding of the scientific approach to enquiry.	Predicting. Ability to create a testable hypothesis. Ability to design an experiment. Interpreting data: graphs and tables. Interpreting data: ability to construct an argument from data. Creating appropriate graph from data. Problem solving/critical thinking. Understanding basic statistics. Questioning. Being able to infer plausible reasons for failed experiments.

Method

For this study we selected a quantitative research design with a qualitative component to obtain insight into student teachers' views of the importance of SPS. This enabled us to compile frequencies of the scientific skills involved in practicals that student teachers found interesting. Previous investigations of SPS have used survey instruments to assess teachers' perceptions (for instance, Rambuda & Fraser, 2004).

Our questionnaire (see Appendix A) included the SPS stipulated in the South African science curriculum (DoE, 2002), particularly those that Molefe (2011) found in a previous study to be challenging to high school learners. The questionnaire provided quantitative data on the importance of 14 SPS for teacher education programmes (measured on a five-point Likert scale) as perceived by the respondents, as well as their choice of most and least important SPS. The qualitative component of the questionnaire obtained information regarding participating student teachers' views of practical activities they found most interesting. We used this information to identify the SPS embedded in these activities. Respondents were also asked to indicate which of the three courses (Biological Science for Educators, Natural Sciences Learning Area or Physical Science for Educators) they were registered for.

We believe that this particular structure of the questionnaire produced the data we required to answer the research questions. According to Coil et al. (2010), participants' perceptions about SPS may be inferred from questions that include Likert scales. The questions were drawn from an instrument designed and validated by Coil et al. (2010). However, it should be noted that the partcipants in this study were provided with definitions of the SPS on the questionnaire to assist in their understanding of the skills.

Sample

The sample comprised 75 student teachers in their third- and fourth-year Bachelor of Education degree and registered for one of the three Science Education courses (i.e. Biological Science for Educators, Physical Science for Educators and Natural Science Learning Area). The biology and natural sciences groups consisted of 31 students each while physical science group consisted of 13 students. The questionnaire was administered to respondents during lectures and took one hour to complete. Permission was sought from the teacher educators who taught these courses, and volunteers were asked to give their consent before participating in the project. All respondents who agreed to participate were assured of total anonymity, and were informed that their participation was completely voluntary and that they were free to withdraw at any time without negative consequences. Ethical clearance was granted by the ethics committee of the university at which the research was conducted (HSS/0249/013).

Data Analysis

The data obtained from the questionnaire with regard to the importance of SPS were analysed and examined using descriptive statistics such as means and frequencies before looking at differences between courses. Enumeration and statistical analysis may be incorporated into qualitative data analysis (Dey, 1993). Enumerating (putting numbers on the students' responses) provided the basis for quantifying data that enabled us to compile frequencies of scientific skills elicited from qualitative data on practicals the students found interesting. The trustworthiness of the data was thus achieved through descriptive statistics and quantifying qualitative data in this way.

Results

The results that enabled us to answer the first research question - *How do student teachers view selected SPS in terms of their importance for them to acquire in their teacher education programmes?* - are presented in Table 2.

Table 2 Participants' perceived importance of 14 SPS for them to acquire in their teacher education programmes (*n* = 75)

Scientific Process Skills	Frequency of occurrence (%)						
	Very important	Important	Moderately important	Of little importance	Unimportant	*M*	*SD*
Problem solving/critical thinking	83.56	13.70	2.74	0	0	3.81	.461
Measuring	67.57	29.73	2.70	0	0	3.65	.535
Interpreting data: graphs and tables	72.00	20.00	6.67	1.33	0	3.63	.673
Interpreting data: ability to construct an argument from data	68.00	24.00	8.00	0	0	3.6	.637
Creating appropriate graph from data	65.33	29.33	5.33	0	0	3.60	.593
Ability to design an experiment	69.33	20.00	9.33	1.33	0	3.57	.720
Questioning	58.15	39.19	2.70	0	0	3.55	.553
Observing (and comparing)	66.20	24.32	8.11	1.36	0	3.55	.705
Recording and communicating information	60.81	33.78	5.41	0	0	3.55	.600
Ability to create a testable hypothesis	52.70	39.19	8.11	0	0	3.45	.644
Understanding basic statistics	42.47	47.94	9.59	0	0	3.33	.647
Classification	44.00	37.33	18.67	0	0	3.25	.755
Predicting	44.00	38.67	16.00	1.33	0	3.25	.773
Being able to infer plausible reasons for failed experiments	44.00	40.00	10.67	5.33	0	3.23	.847

Note: The table is arranged in descending order of means starting with the highest so as to indicate the skills considered most important overall.

We acknowledge the importance of student teachers' conceptual knowledge and competencies with regard to the acquisition of SPS. However, in this study we chose to focus on the teachers' views and perceptions - as a follow-up to the previous study conducted with their educators (Molefe & Stears, 2014). Table 2 shows the frequencies for importance attached to each SPS, based on respondents' experience of practical work, class-room activities and assessment practices. Respond-ents appear to view most skills as being important because the most common options ticked for all SPS were either "important" or "very important".

In order to verify the perceived importance attributed to each SPS (Table 2), respondents were asked to select four skills from the list of 14 skills that they considered to be the most important for them personally to acquire, and the four skills that they considered to be least important to acquire. Table 3 shows the overall ranking of the SPS, with the frequency being the count of the number of times that the skill was selected as one of the four most or least important. A very strong negative correlation between the selection of the most important and the least important SPS (Spearman's correlation coefficient = -0.946) shows that the respondents were consistent with regard to the SPS they selected. The SPS selected most frequently was *problem solving/critical thinking* (51), followed by interpreting data (*graphs and tables*) (37), *observing (and comparing)* (37) and *ability to design experiments* (27).

When the overall ranking of SPS as important for student teachers to acquire in teacher education programmes and respondents' selection of most and least important SPS for them to acquire personally, were compared, some interesting findings emerged. Only two skills, *problem solving/critical thinking* and *interpreting (graphs and tables),* were found to be in the top four skills for inclusion in their teacher education programmes as well as for their personal acquisition. The skill of *measuring* was seldom identified by the students as one of the four most important to acquire personally, despite being placed second (Table 2) in their overall ranking of the 14 skills to be acquired in their teacher education programmes. The skill of *observing (and comparing)* was considered to be one of the four most important skills to acquire personally (ranked second in Table 3, together with *interpreting* [graphs and tables]), but was only ranked by respondents as 8th in importance to attain in their teacher education programmes. The ranking of least important skills, on the other hand, were similar to the ranking for personal acquisition in teacher education programmes.

Table 3 Skills chosen as most important and least important by participants (*n* = 75)

Skill	Frequencies	
	Most important	Least important
Problem solving/critical thinking	51	3
Interpreting data: Graphs and tables	37	16
Observing (and comparing)	37	13
Design an experiment	27	11
Raising questions	23	18
Interpreting data: Construct an argument from data	19	13
Hypothesising	19	12
Recording and communicating information	18	26
Creating graphs from data	16	12
Measuring	14	20
Predicting	13	32
Understanding basic statistics	8	39
Classification	7	37
Infer reasons for failed experiments	7	32

Note: Items are arranged in terms of the frequency of the most important skills (*n* = 75).

The results which enabled us to answer the second research question, '*how do student teachers enrolled in different science courses view SPS in terms of their importance for them to acquire in those courses?*', were obtained by determining if there were differences in the rating of the 14 skills among respondents in the three science courses in terms of their inclusion in their teacher education programmes. An ANOVA test revealed only two statistically significant differences in the mean importance attributed to each of the 14 SPS between Biological Science for Educators, Physical Science for Educators and Natural Science Learning Area student respondents. Problem solving/ critical thinking was given more importance by the Biological Science respondents (M = 3.93) than the Natural Sciences respondents (M = 3.63) with p = 0.041. *Predicting* was given more importance (M = 3.48) by the Natural Sciences respondents than by the Physical Science respondents (M = 2.82) with p = 0.048. The other 12 differences, however, are statistically insignificant, which justified our choice of grouping all respondents together.

The results that enabled us to answer the third research question, *'what SPS are foregrounded in the practical activities student teachers find most interesting?*', are presented in Table 4.

Respondents were asked to identify and provide reasons for the most interesting practical (laboratory) activity in which they engaged that term. Their responses were analysed and categorised according to the SPS that they conceivably developed when engaging in that particular practical activity. We used the skills listed in Table 1 and/or Figure 1 as a guideline for the selection of SPS. Of all the activities respondents mentioned as interesting, we only identified 36 instances where SPS were embedded in the activities in which the respondents engaged. Table 4 presents examples of respondents' responses indicating a possible skill, as well as the skills according to the frequency of their responses. *Observing (and comparing)* and *interpreting (ability to construct an argument from data)* were recorded more than any other skill, with *observing (and comparing)* identified most often in respondents' responses.

Interpreting emerges as the skill embedded in most interesting activities, as well as the skill that students found to be important in their teacher education programmes and for their personal acquisition. However, this skill has different applications in the two instances. In teacher education programmes and for personal acquisition, interpreting is regarded as important with regard to interpreting graphs and tables, while in interesting activities, interpreting emerged in activities related to constructing an argument from data.

Discussion and Conclusion

Over the last 10 years, various studies on SPS have focused on students' conceptual knowledge and/or performance on SPS (Gürses, Cuya, Günes & Doğar, 2014; Karamustafaoğlu, 2011; Kelly, 2013; Myers & Dyer, 2006). We decided to tap into student teachers' views regarding the importance they attached to these skills, and the associated praxis framed on their development.

The student teacher respondents in this study regarded most skills as important for acquisition in teacher education programmes. The contradiction between their ranking of the 14 SPS and their choices of most important skills for them to acquire personally, merits attention. This was particularly true for *measuring* and *observing (and comparing)* (see Tables 2 and 3). If respondents did not think *measuring* was particularly important for them to acquire, it raises the question as to why they ranked it second out of the 14 SPS. The contradiction in the ranking of *observation (and comparing)* (see Tables 2 and 3) is even more difficult to explain. Miles's (2010) study suggests that teachers may be less interested in measuring and observation, as they are among the most familiar basic SPS. This dissonance between the SPS, which respondents found most important to acquire personally and those ranked out of 14, requires further research. The development of critical thinking, as both part of life skills and as an educational concept, is enshrined in the principles of the South African science curricula (e.g., DBE, 2011; Warnich & Meyer, 2013). Warnich and Meyer (2013) add that the development of critical thinkers remains one of the key issues facing educators today. Problem solving and critical thinking are linked (DBE, 2011). It is thus reasonable that the present findings show that students ranked *problem solving/critical thinking* very highly for their personal acquisition. Similarly, *interpreting data (graphs and tables)*, ranked second by respondents, is also included in the list of essential SPS in the South African sciences curricula (DBE, 2011).

Table 4 Frequency of SPS associated with interesting practicals ($n = 50$)

Sample student quotes	Science process skills	Frequency
"To observe salt being crystallised … and do this investigation [separation techniques] by yourself made the content in the book much more easier [sic] to understand"	Observing (and comparing)	21
"I did not know before that ['construct our own DNA'] that I can actually show my learners that in science everything is not just theory where you just take as it is, but it goes beyond to doing what you learn and to investigate phenomena and actually draw a conclusion to what you tried and tested to prove its true" [sic]	Interpreting data: ability to construct an argument from data	5
"We were asked to predict and test whether the given materials were good conductors or poor conductors of electricity"	Predicting	3
"Doing this practical answered long held questions in my head [related to] ... DNA which is traced to be similar to chimpanzees"	Questioning	3
"It [practical on separation techniques] ... allowed us to hypothesise"	Ability to create a testable hypothesis	2
"I was very amazed [sic] looking at live organisms under the microscope ... I was able to identify the organisms using the key chart"	Classification	2

Our previous research (Molefe & Stears, 2014) provided some understanding of the link between science teacher educators understanding of SPS and their conceptions of teaching and learning. In that study, *observing (and comparing)* and *interpreting (ability to construct an argument from data, graphs and tables)* were rated highly by the respondents. In the present study, *observing (and comparing)* and *interpreting data (ability to construct an argument from data)* were identified more than any other skill, in respondents' responses regarding interesting practical activities. Our findings suggest that the respondents' choices of the skills, in terms of their importance for them to acquire in their teacher education programmes, were based on their educators' patterns of praxis. This could possibly be the case because educators may consciously or unconsciously choose to facilitate the development of these particular skills, so respondents will have engaged in activities featuring these skills. We have not presented data on teacher educators as our research focused on student teachers. For empirical evidence see Molefe and Stears (2014). However, we are of the view that this observation merits mention here.

Although interpreting appears to be at the heart of both the activities viewed as interesting and the important SPS to attain in teacher education programmes and for personal acquisition, it has different applications. The applications thereof suggest little theoretical connection between interest and importance. This has implications for the design of teacher education programmes in relation to development of SPS. On the other hand, while the finding on *observing (and comparing)* is not unexpected, it does reinforce the need for teacher educators to include a spectrum of SPS in their teaching. Students who are aspiring teachers need to be exposed to the full bouquet of SPS skills to enable them to become competent science teachers. Gürses et al. (2014) support the notion that higher education students' awareness levels regarding SPS should be enhanced in order to improve their application potential.

The findings make a contribution to science education in terms of a possible link between praxis and students' learning through their own "apprenticeship of observation", that is, learning about teaching through observation, which is more intuitive and imitative (Lortie, 1975). The findings allude to the central role that teacher educators play pedagogically in pre-service science education, as their praxis could influence development of students' SPS.

Competency in SPS will only be achieved if teacher educators consider the types of laboratory activities they design for students and focus on the particular SPS embedded in each activity. Explicitly stating which SPS is included in each activity and an explanation of how this particular SPS may be acquired, will contribute to a better understanding by students of what each skill means and how to achieve competency in this skill. It is incumbent upon teacher educators to ensure that student teachers acquire the necessary SPS to, in turn, enable their learners to become the problem-solvers and critical thinkers South Africa requires, especially in the light of the fact that, despite reforms in South Africa with regard to skills, teachers still favour science content over SPS development (Ambross, Meiring & Blignaut, 2014).

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Appendix A

QUESTIONNAIRE ON SCIENCE PROCESS SKILLS
(Adapted from Coil et al., 2010)

Student name: ....

Tick (✓) the course you are referring to in the questionnaire

COURSE	
Biological Science for Educators	
Natural Science Learning Area	
Physical Science for Educators	

Question 1: Please describe the laboratory activity that you performed in this term that you found to be most interesting – and why you chose it.

QUESTION 2: Please rank (✓) the skills in the table according to their importance for student teachers to attain during their studies toward a degree in education.

For example: A scientific skill may qualify as important if it has been *taught in class*, been developed during laboratory work, or has been included in a question asked in a *test/examination*.

SCIENTIFIC SKILLS	Very important	Important	Moderately important	Of little importance	Unimportant
Interpreting data: graphs and tables					
Understanding basic statistics					
Questioning: raising questions that are testable, measurable and repeatable					
Observing (and comparing): proficiency in describing patterns and ordering and sequencing events					
Interpreting data: ability to construct an argument from data					
Ability to create a testable hypothesis					
Measuring: understanding concepts of accuracy and precision					
Ability to design an experiment: identifying and controlling variables					
Problem solving/critical thinking					
Recording and communicating information: understanding forms of information or data representation (i.e., verbal, written, pictorial and mathematical forms)					

SCIENTIFIC SKILLS	Very important	Important	Moderately important	Of little importance	Unimportant
Classification: grouping and organising objects or attributes					
Predicting: forecast future observations on the basis of present trends or previous knowledge					
Being able to infer plausible reasons for failed experiments					
Creating appropriate graph from data					

QUESTION 3: If you could choose (✓) only 4 of the following skills to focus on, which are ***the most important*** for YOU to acquire.

SCIENTIFIC SKILLS	Most important (Tick 4)
Interpreting data: graphs and tables	
Understanding basic statistics	
Questioning: raising questions that are testable, measurable and repeatable	
Observing (and comparing): proficiency in describing patterns and ordering and sequencing events	
Interpreting data: ability to construct an argument from data	
Ability to create a testable hypothesis	
Measuring: understanding concepts of accuracy and precision	
Ability to design an experiment: identifying and controlling variables	
Problem solving/critical thinking	
Recording and communicating information: understanding forms of information or data representation (i.e., verbal, written, pictorial and mathematical forms)	
Classification: grouping and organising objects or attributes	
Predicting: forecast future observations on the basis of present trends or previous knowledge	
Being able to infer plausible reasons for failed experiments	
Creating appropriate graph from data	

QUESTION 4: Which of the following skills are ***the least important*** for YOU to acquire? Please choose (✓) 4.

SCIENTIFIC SKILLS	Least important (Tick 4)
Interpreting data: graphs and tables	
Understanding basic statistics	
Questioning: raising questions that are testable, measurable and repeatable	
Observing (and comparing): proficiency in describing patterns and ordering and sequencing events	
Interpreting data: ability to construct an argument from data	
Ability to create a testable hypothesis	
Measuring: understanding concepts of accuracy and precision	
Ability to design an experiment: identifying and controlling variables	
Problem solving/critical thinking	
Recording and communicating information: understanding forms of information or data representation (i.e., verbal, written, pictorial and mathematical forms)	
Classification: grouping and organising objects or attributes	
Predicting: forecast future observations on the basis of present trends or previous knowledge	
Being able to infer plausible reasons for failed experiments	
Creating appropriate graph from data	