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Learner Perceptions of Inquiry in Science Fair Projects: A Case Study of a Regional Science Fair in South Africa

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ABSTRACT The purpose of this study was to compare 334 learners' experiences of scientific inquiry in science fair projects and science classrooms. A mixed methods design was used involving a survey questionnaire with closed and open-ended items. The closed items measured the extent to which learners experienced inquiry in science fair projects and science classrooms. The open-ended items identified the main sources of science classroom and science fair project support. Findings were that the science fair projects were perceived to have offered significantly more inquiry experiences than the classroom. Internet and laboratory access, teachers, middle-class parents and public facilities such as libraries, Internet cafes, and science centers were the main sources of support. Recommendations are that science fairs should be reconfigured to allow for mass participation. School laboratory, library and IT infrastructure must be expanded to reduce inequalities in learners' cultural capital. Inquiry-based professional development support should be offered to teachers.

INTRODUCTION

There has been worldwide dissatisfaction with the quantity and quality of practical work in school science education despite the wide acceptance of its importance as a bridge between theoretical science and empirical evidence (Ling and Towndrow 2006). Quantitatively, there has been a decline in the number of experimental activities carried out with teachers focusing mainly on what works for assessment while qualitatively, there has been a loss of much of the inquiry and process emphases of the past (Dillion 2008). Practical work has thus largely been reduced to a recipe-following format to reach predetermined results with little intellectual input from the learners (Hodson and Benze 1998; Ling and Towndrow 2006; Haigh 2007). This has resulted in the theoretical teaching of science which is an antithesis to the nature of science (NOS) alluded to in the literature (for example, Abd-El-Khalick 2012; Capps and Crawford 2013).

In the South African context the situation has fared no better in that more emphasis has been placed on routine science problems in a system where many of the teachers are not adequately qualified to teach the subject (Hobden 1998; Human Sciences Research Council (HSRC) 2012). Kahn (2011) concedes that post-apartheid efforts at teacher training have largely failed and Reddy (2006) observes that although South African teachers were the most in-serviced the country still underperformed in TIMSS 2003 (Trends in International Mathematics and Science Study). The low ranking in international benchmark mathematics and science tests, and global competitiveness reports has been a constant feature (for example, Martin et al. 2012; Mullis et al. 2012; HSRC 2012; Schwab 2015; Dutta et al. 2015; Coughlan 2015). Efforts to offer learners high quality science education have been hampered by inadequate infrastructure and resources. For example, Martin et al. (2012: 247) report that only forty- four percent of grade 8 learners attended a school with a science laboratory in South Africa and only forty-two percent of teachers had assistance available when learners were conducting experiments.

Severe backlogs have been experienced more persistently in mathematics and science. For example, grade 9 science teachers in South Africa reported having implemented only sixty- two percent of the Revised National Curriculum Statement (RNCS) syllabus and only the most proficient among South African learners approached the international average in TIMSS 2011 (HSRC 2012). The Expo for Young Scientists (Expo), a science fair organized annually in South Africa and sponsored by the country's power utility, ESKOM (Electricity Supply Commission), provides learners with an opportunity to experience more authentic inquiry science over and above what they experience in the classroom (Alant 2010; Taylor 2011).

Scientific inquiry or inquiry-based learning requires learners to frame their own questions design and implement their own procedures, draw conclusions and results from evidence and mathematical and analytical tools to derive a scientific claim (Olson and Loucks-Horsley 2000; Lunetta et al. 2007; National Research Council (NRC) 2000, 2012). In its Curriculum and Assessment Policy Statements (CAPS) for science, the Department of Basic Education (DBE) (2011) defines an investigation as an experiment to test a hypothesis the outcome of which is not known beforehand. Scientific investigations, therefore, enable learners to experience authentic inquiry in their science education. The Center for Pedagogy (SUNCEP) annually organized the regional expo as a part of Stellenbosch University's community engagement program.

Investigative and Inquiry Work in School Science

Scientific investigations offer learners the opportunity to conduct complete scientific inquiry into authentic questions generated by them to achieve a depth of understanding of core ideas (National Research Council 2012; Llewelyn 2014). However, inquiry is often inadequately understood by teachers many of whom have had very little or no experience of it at both school and undergraduate levels (Windschitl 2002; Melville et al. 2008; Levy et al. 2013; Llewellyn 2014). In their attempt to simplify inquiry instruction, Bell et al. (2005) emphasize that not all inquiry activities are created equal nor are all worthwhile activities necessarily inquiry-based. They have built on Schwab's (1962) different levels of inquiry, Herron's (1971) model of three levels of inquiry, Rezba et al.'s (1999) four levels of inquiry instruction, as well as the NRC (2000) inquiry rubric, to arrive at a two-dimensional four-level framework of inquiry.

The first dimension of the model deals with the degree of structuring or amount of information provided to the student (research question, method and/or solution), resulting in a continuum ranging from highly teacher-directed to highly learner-directed activities. A Level 1 inquiry (Rezba et al. 1999) is referred to as *confirmation*, wherein learners are provided with the question, follow a predetermined procedure and expected results are known in advance. A Level 2 investigation is *structured inquiry* in which learners investigate a teacher-presented question through a prescribed procedure. A Level 3 investigation is *guided inquiry* where learners investigate a teacher-presented question using learner designed or selected procedures. A final or Level 4 investigation is *open inquiry* in which learners investigate their own questions on a topic through learner-formulated procedures to obtain their own (unknown) results. Bell et al. (2005) point out that science fair projects are the most common form of Level 4 inquiries in that learners investigate learner-formulated, topic-related questions and use their own procedures to arrive at their own results. The differential provisioning of information 'allows the teacher to tailor inquiry lessons to the particular readiness levels of the class' (Bell et al. 2005: 31) as part of scaffolding inquiry from one level to the next. For example, a Level 1 activity can become a Level 2 activity if learners complete it prior to learning the targeted concept and a Level 2 activity can be revised to Level 3 by removing the procedural prescriptions. In other words, as learners gain knowledge and confidence, the constraints of inquiry can be relaxed for increased learner independence (Toth et al. 2009). However, since the principles of inquiry in this study refer to five categories identified by Campbell et al. (2010), Table 1 shows a modified version of Bell et al.'s (2005) model to include semi-structured inquiry as Level 3 and partly guided inquiry as Level 5 thus elevating open enquiry to Level 6.

The second dimension is that of complexity or the level of openness and the cognitive demands (Bell et al. 2005), which varies from low-level (confirmatory inquiry) to high-level (open inquiry) activities. Students cannot be expected to conduct high-level inquiry investigations if they have participated exclusively in low-level activities in the science classroom throughout the year (Bell et al. 2005; Llewellyn 2014). They will need practice in inquiry, building up to increasingly more open and more complex levels. Learners will reap as little benefit from being thrown unprepared into open inquiry activities, as they will from being held at low-level activities (Bell et al. 2005). This is instructive for teacher education and development. For example, both teachers and teacher educators need to be acutely aware of inquiry-oriented lab styles such as those alluded to by Baseya and Francis (2011).

Table 1: Six-level model of inquiry for this study

	Level of inquiry	*How much information is given to the learner?* Framing research questions?	Design of investigation?	Conduct of investigation?	Data collection?	Drawing conclusions?
Teacher-directed	1–Confirmation	✓	✓	✓	✓	✓
↕	2–Structured	✓	✓	✓	✓	
	3–Semi-structured	✓	✓	✓		
	4–Guided	✓	✓			
Learner-directed	5–Partly-guided	✓				
	6–Open					

Bourdieu's Cultural Capital Theory as a Lens for Interpreting Sources of Additional Support Received by Learners

Bourdieu (1986, 1987) refers to four different forms of capital, which he terms fundamental social powers. They include economic capital consisting of financial resources (for example, occupation as an economic indicator), cultural capital consisting of informational resources (for example, linguistic and scientific resources), social capital consisting of resources based on connections and group membership (for example, occupation as indicator of position in social space), and symbolic capital consisting of the form the different types of capital take once they are perceived and recognized as legitimate. He argues that the relative value of the different species of capital is continually being debated (Bourdieu 1987). Sullivan (2007) points out that Bourdieu's cultural capital can loosely refer to cultural traits that help people to gain educational success. She further adds that the possession of cultural capital varies with social class. In other words, the influence of cultural capital on educational participation cannot be discussed in isolation of social capital, which, in turn is determined to a large extent by economic capital. By analyzing learners' responses regarding the kind of school and out-of-school support they received or actively sought, this study might provide insight on how learners can differentially accumulate capital to effectively participate in the science fair and hence, potentially obtain a richer experience of inquiry science, or otherwise.

Objectives and Research Questions of the Study

The aim of this study was to investigate science fair learners' perceptions of inquiry in their science classrooms and in science fair projects. More specifically, the following research sub-questions guided this study:

a) How do participating learners perceive their experience of scientific inquiry to be in their science classrooms in relation to learner-centeredness and teacher-centeredness?
b) How do the learners perceive their experience of scientific inquiry to be in their science fair projects in relation to learner-centeredness and teacher-centeredness?
c) How do the two experiences differ from each other?
d) What do the learners indicate to be their main sources of school and out-of-school support?

METHODOLOGY

Sample

In this study, a total of 334 grade 7 to 12 out of 360 learners from 34 schools, which participated in the 2012 Stellenbosch Regional Expo for Young Scientists, volunteered to complete the questionnaire. This constituted a relatively high return rate of ninety three percent. Traditionally, learners have been regarded as consumers of readymade scientific knowledge and not worth consulting, a neglect that Rudduck and Flutter (2000) contend sat increasingly uncomfortably alongside the market philosophy espoused in many societies today. Accommodating the learners' voice about the quality of their school science education involves seeing them less as part of the problem of raising standards in school science and more as a key element in its resolution (Jenkins 2006).

Questionnaire

The survey questionnaire method was chosen to cover as many participants as possible during the limited time of the science fair. Campbell et al.'s (2010) Principles of Scientific inquiry (PSI-S), a semantic scale, Likert-type questionnaire for learners, was adapted and split into a two-part questionnaire. Both parts consisted of 20 questions apiece which sought to elicit learner perceptions of scientific investigations in the science classroom and in the science fair project respectively as well as open-ended questions, which sought to solicit information about additional sources of support received or sought to conduct the scientific investigations in the classroom or the science fair project, as an indication of the nature of resources or cultural capital that they had accumulated or taped into. Another modification was to change 'student' to 'learner' in keeping with the South African educational parlance. The 5-point semantic scale ranged from '1 - Almost Never' to '5 - Almost Always'. The administration of two similar questionnaires simultaneously amounted to a retrospective pre- and post-test design which has the advantage of counteracting response-shift or change in the internalized standard by which a subject rates himself (Pohl 1982) The learners could therefore compare their science fair project experience with their routine classroom experience of science by the same standards.

Questionnaire Reliability

As already noted earlier, the first part of the questionnaire was a slight modification of Campbell et al.'s (2010) questionnaire to solicit learner perceptions of inquiry experiences in science classrooms. The Cronbach alpha reliability obtained by Campbell et al. (2010) for this instrument was 0.82 for 130 high school science learners which, according to conventional limits for reliability estimates (that is, Nunnally and Bernstein 1994), equated to a high level of internal consistency. In this study involving 334 learners the estimate obtained was 0.89 for classroom experience (Part 1) and also equated to a high level of internal consistency. Part 2 of the questionnaire had identical categories and the same number of items as the first part with the only difference being the changes in the wording to solicit self-reported learner perceptions of the science fair project. The estimate for the 334 learners in this study was 0.89, which also equated to a high level of internal consistency.

RESULTS

Quantitative Results

Learner Perceptions of Scientific Inquiry in the Science Classroom

Table 2 summarizes responses to the first part of the questionnaire with questions grouped according to the five inquiry principles as outlined in Campbell et al. (2010), namely framing research questions (A1-A4), designing scientific investigations (B1-B4), conducting scientific investigations (C1-C4), collecting data (D1-D4) and drawing conclusions (E1-E4).

On average the learners' involvement in formulating research questions that can be answered by scientific investigations (A1) was rated closer to 'Often' than 'Sometimes' but the

Table 2: Learner perceptions of inquiry in science classroom, N=334

PSI-S Question	*A1*	*A2*	*A3*	*A4*	*B1*	*B2*	*B3*	*B4*	*C1*	*C2*
Classroom experience	3.86	3.36	4.21	3.84	4.14	3.95	3.79	3.74	3.92	3.63
Standard deviation	0.921	1.018	1.032	0.990	0.987	0.975	0.938	0.910	0.965	1.283
PSI-S Question	*C3*	*C4*	*D1*	*D2*	*D3*	*D4*	*E1*	*E2*	*E3*	*E4*
Classroom experience	4.05	3.88	3.77	3.82	4.11	3.79	4.23	3.92	4.08	4.09
Standard deviation	0.975	1.025	1.055	0.936	0.874	0.970	0.923	0.988	0.900	0.938

Key to Questions: A1-Learners formulate Qs; A2-Learners' Qs lead lab; A3-Learners frame own Qs; A4-Lerners refine Qs; B1-Learners given procedures; B2-Learners design own procedures; B3-Learners evaluate procedures; B4-Learners justify Qs; C1-Learners conduct procedure; C2-Teacher conducts procedure; C3-Learners participate actively; C4-Learners have lab role; D1-Learners choose data; D2-Learners take notes; D3-Learners understand rational for data; D4-Learners decide data stages; E1-Learners draw own conclusions; E2-Learners interpret evidence variously; E3- Learners connect findings to existing knowledge; E4-Learners justify conclusions use of the research questions to determine the direction and focus of the laboratory activities (A2) was rated closer to 'Sometimes'. Encouragement of learners to frame their own research questions (A3) was rated as occurring slightly more frequently than often while time devoted to refining learner questions (A4) was rated slightly below often. The reliability estimate for questions in this category was moderately high at 0.76. The rating on whether learners were given step-by-step instructions before they conducted investigations averaged above often while learner opportunities to design their own procedures was rated marginally below often showing greater presence of teacher direction than learner direction in methodological design. Engagement of learners in the critical assessment of procedures (B3) and justification of their appropriateness (B4) were both rated closer to 'Often' than 'Sometimes'. The reliability estimate for questions B1-B4 was a moderate 0.61. Learners nearly often conducted their own procedures of an investigation (C1) but at the same time, surprisingly, rated teacher conduct of experiments and investigations in front of the class (C2) as occurring almost as frequently. Learners, however, actively participated in investigations as they were conducted (C3) a little above often times even though individual learners' participation (C4) was less frequent. The reliability estimate of the questions in this category of conducting experiments was unsurprisingly low at 0.41. Learner involvement in data collection (Category D) and drawing of conclusions (category E) were perceived as occurring more than often across the board. The respective reliability estimates for these categories were moderately high at 0.71 and high at 0.81. By applying a scale of Very Low ($1<x<2$), Low ($2<x<3$) Moderate ($3<x<4.$), High ($4.0<x<4.5$), Very High ($4.5<x<5$) it can be concluded that the formulation of research questions, design and conduct of investigations, and the gathering of data were moderately high in the classroom whereas the drawing of conclusions by learners was perceived to be occurring at a high level of frequency. This would make classroom experience of scientific investigations semi-structured, minimally learner-directed and largely teacher-directed.

Learner Perceptions of Scientific Inquiry in Their Science Fair Projects

Table 3 summarizes responses to the second part of the questionnaire with questions grouped into five categories as in the first part.

On balance, the category of learner involvement in formulating research questions (Category A) was rated as having occurred very often across the board with respect to the science fair project scientific investigation. The reliability estimate for questions in this category was high at 0.81. The rating on whether learners were given step-by-step instructions before they conducted investigations averaged fractionally below often while learner opportunities to design their own procedures (B2), engage in critical assessment of their procedures (B3) and justifying them (B4) were all rated to have occurred greater than often. The reliability estimate for questions in the Category B was a moderate 0.57. Learners more often than not conducted their own procedures of the science fair project investigation (C1), actively participated as the investigation was conducted (C3) and each had a role, as the investigation got under way (C4). Learners unsurprisingly rated teacher involvement in the conduct of investigations (C2) as having occurred midway between seldom and sometimes. The reliability estimate of the questions in this category of conducting experiments was very low at 0.04 owing to the strong negative correlation with C2. Learner involvement in data collection (Category D) and drawing of con-

Table 3: Learner perceptions of inquiry in science fair projects, N=334

SI-S Question	*A1*	*A2*	*A3*	*A4*	*B1*	*B2*	*B3*	*B4*	*C1*	*C2*
Expo experience	4.44	4.33	4.36	4.22	3.98	4.36	4.15	4.11	4.28	2.53
Standard deviation	0.933	1.027	1.045	1.000	1.002	0.989	0.95	0.923	0.979	1.291
PSI-S Question	*C3*	*C4*	*D1*	*D2*	*D3*	*D4*	*E1*	*E2*	*E3*	*E4*
Expo experience	4.49	4.47	4.41	4.18	4.44	4.27	4.48	4.19	4.33	4.44
Standard deviation	0.99	1.035	1.066	0.948	0.891	0.982	0.94	0.995	0.913	0.952

Key to Questions: As for Table 2.

clusions (Category E) were perceived as having occurred more frequently than often across the board. The respective reliability estimates for these categories were high at 0.81 apiece. Applying the same scale of Very Low (1<x<2), Low (2<x<3) Moderate (3<x<4.), High (4.0<x<4.5), Very High (4.5<x<5) it can be concluded that the formulation of research questions, design of investigations, gathering of data were perceived to have occurred at a high level of learner autonomy in the science fair project whereas the conduct of investigations was perceived to have occurred at a moderately high level of independence. This would make the learners' perception of the science fair's scientific investigations to have been more learner-directed and much less teacher-directed. This is more so considering the strong negative correlation of question C2 (teacher conduct of investigation). The level of the open-endedness can be tentatively rated as having been partly guided in that learners got assistance with refining their research questions and the design of the investigations and carried out the rest of the steps on their own.

Comparison of the Science Classroom Experience with the Science Fair Experience

Table 4 shows raw differences in individual question means of the learners' perceptions of inquiry in their classroom and science fair project. The table also shows values for the dependent or paired samples *t*-statistic, the two-tailed *p*-value and statistical significance of the result for each question.

Learners perceived the experience of scientific inquiry in the science fair projects to be significantly different from what they experienced in their normal science classrooms. In fact, the science project experience of inquiry was significantly more than that of the classroom experience. That is, students themselves engaged in the practices of inquiry (National Research Council 2012). However, on their own, significance tests do not adequately inform about the strength of the effect of a treatment, hence growing calls for effect size measures to be reported (for example, Sullivan 2012) as the main finding of a quantitative study. The effect size measure opted for in this study was Cohen's *d* because it is appropriate for data measured on the interval scale of which a semantic scale is one such example.

Table 5 shows the Cohen's *d* values for each question and the corresponding interpretation of the statistic adapted from Cohen (1988). The table also shows the correlation between the means, which must be factored in when within-subject comparisons are made (Morris and DeShon 2002). As can be seen, only three questions (A3, B1 and E2) had trivial effect sizes. The rest of the questions either had small or medium effects, the highest effect sizes being for questions C2, A2 and A1 respectively on learner autonomy about framing the research question and conducting the investigation.

Table 6 shows the effect sizes per category of Principles of Scientific Inquiry (PSI). Only category C, for the conduct of the investigation, had a trivial aggregate effect size. The data collection category D had the largest effect size while the category for framing research questions had the second highest effect size, and the rest had small effect sizes.

Table 4: Significance of paired t-test differences in perceptions of inquiry in science classroom and science fair projects per question

PSI-S question	*A1*	*A2*	*A3*	*A4*	*B1*	*B2*	*B3*	*B4*	*C1*	*C2*
Classroom experience	-0.63	-1	-0.18	-0.43	0.2	-0.4	-0.38	-0.37	-0.37	1.11
t stat for 333 df	-13.66	-21.86	-3.77	-8.54	3.09	-8.82	-9.01	-7.77	-7.06	18.11
2-tail p-value	0.0000	0.0000	0.0002	0.0000	0.0022	0.0000	0.0000	0.0000	0.0000	0.0000
Significant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PSI-S question	*C3*	*C4*	*D1*	*D2*	*D3*	*D4*	*E1*	*E2*	*E3*	*E4*
Classroom experience	-0.46	-0.6	-0.67	-0.36	-0.34	-0.47	-0.27	-0.27	-0.3	-0.36
t stat for 333 df	-9.97	-12.65	-14.91	-7.32	-7.88	-10.01	-6.38	-5.36	0.00	-8.05
2-tail p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Significant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Key to Questions: As for Table 2.

Table 5: Effect sizes of differences in perceptions of inquiry in the science classroom and the science fair project per question

PSI-S question	*A1*	*A2*	*A3*	*A4*	*B1*	*B2*	*B3*	*B4*	*C1*	*C2*
Correlation of means	0.035	0.022	-0.020	-0.080	0.139	-0.017	-0.047	-0.014	-0.014	0.030
Cohen's *d*	-0.509	-0.699	-0.121	-0.298	0.151	-0.287	-0.280	-0.282	-0.267	0.704
Effect size	Medium	Medium	Trivial	Small	Trivial	Small	Small	Small	Small	Medium
PSI-S question	*C3*	*C4*	*D1*	*D2*	*D3*	*D4*	*E1*	*E2*	*E3*	*E4*
Correlation of means	0.032	0.103	-0.052	0.017	-0.020	-0.020	0.102	-0.008	0.109	0.082
Cohen's *d*	-0.337	-0.434	-0.434	-0.273	-0.267	-0.340	-0.215	-0.190	-0.244	-0.280
Effect size	Small	Small	Small	Small	Small	Small	Small	Trivial	Small	Small

Key to Questions: As for Table 2.

Table 6: Effect sizes of differences in learner perceptions of inquiry in science classroom and science fair project experience per PSI category

Category	*A*	*B*	*C*	*D*	*E*	*Total*
Classroom experience	3.78	3.91	3.86	3.87	4.06	3.9
SD	0.76	0.65	0.65	0.71	0.75	0.55
Science fair experience	4.34	4.13	3.92	4.29	4.34	4.21
SD	0.84	0.88	0.97	0.81	0.80	0.85
Correlation	-0.02	0.03	-0.01	-0.03	0.09	0.01
Cohen's *d*	-0.73	-0.21	-0.06	0.86	-0.27	-0.32
Effect size	Medium	Small	Trivial	Large	Small	Small

Key to Categories: A - Framing research questions; B – Designing the investigation; C – Conducting the investigation; D – Data collection; E – Drawing conclusions

An oblique rotation performed using version 20 of the Statistical Package for Social Scientists (SPSS) led to a two-factor solution, which accounted for forty-two percent of the variance in the science classroom experience and forty-nine percent of the variance in the science fair project experience. Factor 1, accounted for thirty-four percent of the variance in the science classroom experience and forty-two percent of the variance in the science fair project experience and aligned with 'those aspects of scientific inquiry that have traditionally been overlooked in science instruction, framing of research questions and student designing investigation' (Campbell et al. 2010: 23). The 10 questions loading onto this factor were A1-A4, B2-B4, D1-D2 and D4. The Cronbach's alpha estimates of internal consistency for Factor 1 were 0.83 for science classroom experience and 0.89 for the science fair experience representing a high degree of internal consistency between the items. Factor 2, accounted for eight percent of the variance in the science classroom experience and seven percent of the variance in the science fair experience and aligned with 'those aspects of traditional methods of instruction that teachers are more comfortable employing, learners conducting investigations and drawing conclusions' (Campbell et al. 2010: 23). The 10 questions loading onto this factor were B1, C1-C4, D3, and E1-E4. The Cronbach's alpha estimates of internal consistency for Factor 2 were 0.76 for the science classroom experience and 0.71 for the science fair experience representing a moderately high degree of internal consistency.

Qualitative Results

Good research practice obligates the researcher to triangulate in order to enhance the validity of research findings (Mathison 1988). In the spirit of that obligation, the open-ended sections of the questionnaire were analyzed to determine the sources of support for their inquiry experiences, and more importantly to gain insight into the nature of resources or accumulated cultural capital at the disposal of the learners. Only a total of 60 learners completed the open-ended sections. The responses were coded and Wordle (an open source word cloud analysis tool) was used to analyze the patterns of support, reported to have been received by learners.

Science Classroom Experience

Figure 1 shows the word cloud for sources of support or accumulated socio-economic-cultural capital that the learners utilized during their science classroom experience. The dominant sources of support included using the school, home or public Internet connectivity, the laboratory, library and science center infrastructure, as well as parents. It can be noted that some learners pointed to the lack of labs and/or proper lab equipment at their schools, and the conduct of very few experiments as hampering their science learning.

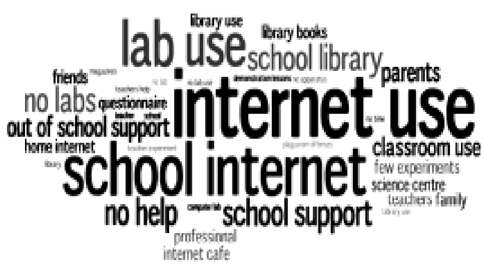

Fig. 1. Learners' narratives of the science classroom experience of inquiry

Examples of learner remarks included the following:

- 'There are labs, but the teacher is doing experiments for us',
- 'The only support comes from parents or the science center',
- 'We went to an internet café to collect information';
- 'Our microscope was provided by the school',
- 'The equipment used is of poor quality',
- 'The Internet was shown to be an important source of information, but school children should be made aware of plagiarism offenses'.

The use of the Internet as an additional support predominated while some evidence of teacher-directed confirmatory investigations also featured confirming quantitative findings. Some learners indicated lack of laboratory facilities, poor equipment or lack of time for laboratory work at school. This was an affirmation of findings by Martins et al. (2012) that less than fifty percent of South African secondary schools have no science labs.

Science Fair Project Experience

Figure 2, shows the pattern of sources of support or socio-economic-cultural capital the learners accessed during the implementation of the science fair project. The home environment per se was the most dominant source of support in multiple ways. Internet use again featured strongly under the sub-themes of 'home Internet', 'school Internet' and 'Internet use' for the science fair suggesting more teacher-independent learner engagement with science.

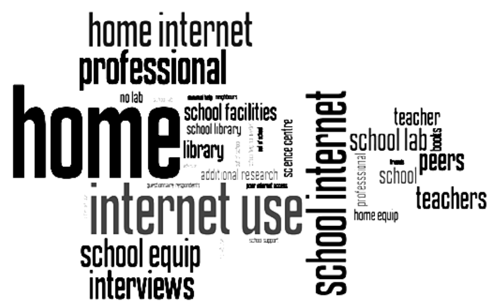

Fig. 2. Learners' narratives of the science fair project experiences of inquiry

Examples of comments given included: 'apparatus at school is limited, all research was done at home', 'My mom and dad help me with my studies', 'I used the Internet and books at home', 'I received support and guidance from my engineer father as well as my expo advisor Mrs X', 'My grandfather helped, guided me to setup and conduct my experiment as it involves working with chemicals'. There was also greater support received from out-of-school sources other than home as shown by such comments as: 'The product designer helped me with the dilution of the concentrate', 'We used Mr X's cryogenic equipment for the science fair project', 'I went to see optometrists', 'I used doctors, physicists, etc. to help and check my hypothesis and conclusion', and 'We joined the West Coast Science Centre and received extra help for the science fair'.

The increased autonomy of the learner and a stronger socio-economic-cultural support system in the science fair investigation was affirmed by learner remarks such as: 'I had minimal help as I believe it is not the prize or acknowledgements you get, but what I have learnt as an individual', 'I made use of Internet facilities at the school, home and library'. On the whole, the results appeared to corroborate differences between science classroom and science fair experience with respect to learner and teacher directedness of scientific investigations.

DISCUSSION

Quantitative results affirm that students perceived classroom experiences to have relatively low levels of inquiry. In particular, the classroom experience appeared to have been more teacher-centered or traditional, than learner-centered or reform-oriented. This lends support to Capps and Crawford's (2013) call for inquiry-based instruction and explicit teaching of the Nature of Science (NOS) as important components of reform-based science teaching. Increased learner participation in the science fairs could widen opportunities for authentic inquiry and authentic experience of NOS. Changing to inquiry-science and explicit teaching of NOS can potentially contribute to improving both student experience of inquiry, engagement in science and achievement. Hence the achievement of South African learners in international benchmark tests (such as TIMSS), can improve and ultimately determine the country's global competitiveness since mathematics and science achievements are designated as economic efficiency enhancing subjects in the global competitiveness reports (Schwab 2015).

From the quantitative results it is also clear that exposing learners to the expo gives them a qualitatively better feel of inquiry science and NOS. Growth in science understanding has the potential not just to enhance scientific literacy but also to enhance achievement in science and ultimately the country's performance and competitiveness in international benchmark tests and indices such as TIMSS or PISA (Martin et al. 2012; Coughlan 2015) and the Global Competitiveness Reports (Schwab 2014, 2015). That the greatest effect size was on framing questions, and on who conducted the investigation, was an indication of the independence of scientific thought and action or intellectual input that the science fair afforded learners. This was consistent with the NRC's conception of inquiry as knowledge validation based on evidence, analysis, and argumentation from many investigations and then integrated into well-tested theories that can explain bodies of data and predict outcomes of further investigations (NRC 2012; Llewellyn 2014).

A comparison of learners' experience of scientific investigations in the classroom and the science fair project based on the identified categories and levels should also sensitize teachers and teacher educators to ways in which teachers can be professionally developed (Capps and Crawford 2013) to adopt what kind of strategies of inquiry approaches (Levy et al. 2013) or what sort of labs (Baseya and Francis 2011) in their professional practice. That ordinary teaching remains stuck in traditional comfort zones lends credence to Windschitl's (2002: 113) concern about the vast majority of pre-service science teachers entering initial preparation programs without having conducted a single inquiry in which they have developed a question of interest and designed the investigation to answer that question. With little exposure to authentic inquiry in their undergraduate education the pre-service teachers graduate to perpetuate traditional approaches in their own classrooms.

The qualitative results explain the kinds of socio-economic-cultural capital resources at the disposal of the learners. For example, some learners did not even have laboratories, some of those with laboratories, did not have equipment, and some of those with equipment did not actually handle the equipment but learnt through teacher demonstrations and manipulation. This indirectly confirms observations by Martin et al. (2012) that far too few schools (only forty-four percent) have laboratories in South Africa and indirectly that inadequately qualified teachers may also be left with minimal assistance to facilitate the conduct of effective learner-centered laboratory work. Qualitative results also highlight the importance of the home environment in promoting inquiry-based learning where socio-economic-cultural capital assets such as Internet access at home, professional parents such as engineers, doctors and teachers, or significant others in the community such as doctors and optometrists, and access to specialized facilities such as science centers, can contribute to the wealth or poverty of the learners' accumulated capital. It makes sense, therefore, for the UN to have declared Internet access as 'an indispensable tool for realizing a range of human rights, combating inequality, and accelerating development and human progress' (United Nations 2011: 22). The differential access to the

Internet by science fair learners and to such basic ICT equipment as computers and laptops as noted by Taylor (2011) implies unequal socio-economic-cultural capital accumulations for success not just for science fair project presentation purposes, but also for mathematics and science education generally.

CONCLUSION

This study set out to investigate the differences in which learners perceived their experience of inquiry science in the science classroom and the science fair project. The findings suggest that learners experienced more scientific inquiry in their science fair projects. The researcher can conclude that learners felt that their normal classroom experiences were significantly more teacher-directed or teacher-centered compared to the science projects. The researcher can also conclude that whereas some schools did not have laboratory facilities, where these facilities existed, mainly teachers did the laboratory work with learners predominantly playing the observer role. It can be concluded that the learners experienced science fair projects as more reform-oriented, scientifically empowering and enabling them to be more resourceful and innovative young scientists.

RECOMMENDATIONS

That some learners reported to be attending schools without laboratories points to the need for policymakers to attend to the provision of school laboratories, Internet and library infrastructure to enable learners to take responsibility for their own learning more effectively. That some learners had access to public facilities such as science centers, Internet cafes, and public libraries, implies the need to bring such facilities to within reach of all learners free of charge at best or at an affordable price at least. That traditional teaching of science is still the dominant paradigm implies the need for professional development or teacher learning that fosters a shift towards inquiry-based learning that is learner-centered and reform-oriented. All stakeholders in teacher education have to share this responsibility. That science fairs offer learners the rare opportunity to experience authentic inquiry calls for efforts to be intensified to ensure mass participation in the expo for young scientists by whatever means feasible including but not limited to decentralization and improved funding models.

Recommendations for further research include understanding the financial implications for decentralization and how these can be ameliorated and the compilation of teacher professional development needs to make the decentralization of the science fairs meaningful and normal classroom teaching more inquiry-based.

LIMITATIONS OF THE STUDY

Since the study was based on a convenient sample of learners who participated at a regional science fair from a limited number of schools in the region, the results cannot be overgeneralized to the population of schools or learners of the entire region. Furthermore, perceptions should be understood to be what they are - perceptions, which might differ from the actual reality, hence requiring other forms of inquiry to uncover.

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