Learners’ participation in science fairs has been encouraged on grounds of affording them opportunities to carry out hands-on practical activities such as scientific investigations oriented towards inquiry science. However, there has been some debate as to the usefulness of the science fair to ill-equipped learners in disadvantaged schools as their cultural capital deficits appear to deny them opportunities to compete on an even keel with learners from historically advantaged schools (where learners have higher accumulations of all forms of capital) in South Africa. The purpose of this study was to conduct an exploratory analysis of some factors influencing student participation and success rate at an ESKOM sponsored Regional Expo for Young Scientists in the Western Cape Province. Participation in the Expo is acknowledged to be one opportunity for learners to competitively experience high levels of scientific inquiry. The study was a quantitative analysis of a convenient sample of 37 schools that participated in the Regional Expo in respect of variables that included distance from the venue, school type (primary, intermediate, combined or high school) gender equity, and poverty quintile categories. Findings were that only 5.1% of eligible schools in the region participated. Distance from the venue was a deterrent for many potential schools. Historically advantaged schools in quintiles 4-5 (higher socio-economic status) did not only have a superior participation rate as a measure of equity, but also a higher success rate as a measure of the quality of participation. Not all schools in the so-called upper quintiles 4-5 category performed well though suggesting that the neglect of scientific investigations or scientific inquiry could be more pervasive than initially assumed thus giving pre-eminence to some other factors. The study recommends democratization of participation through decentralization, increased funding for ICT, laboratory infrastructure, science centres, science fair participation logistics, and increased professional development support for teachers and learners in marginalised schools.

Keywords: Expo for Young Scientists, science fair, principles of scientific inquiry, scientific investigations, the nature of science, cultural capital, school poverty quintile.

1 INTRODUCTION

South Africa’s learner achievement in science and mathematics has consistently fallen short of expectations in both local and international evaluations (e.g. National Senior Certificate, Annual National Assessments, Southern and East African Consortium for Measurement of Educational Quality (SACMEQ) and, most of all, the Trends in International Mathematics and Science Study (TIMSS). The 2003 TIMSS

1 Earlier versions of this paper were originally presented at SAARMSTE 2014 and ICERI 2014 conferences.
report shows that less than a third of the learners watched a demonstration or conducted an experiment or investigation [1]. This is a challenge to all concerned with the effective teaching and learning of science which, in its very nature is a confluence of observation-based disciplinary fields. Mathematics has been touted to be the magnifying glass of science. Much of the low academic achievement of South African students, like in many other parts of the developing world, can be attributed to mathematics and science teachers being inadequately qualified and the lack of properly functioning schools (e.g. [1]; [2]; [3]). Competent teachers are a non-negotiable prerequisite for the effective functioning of school systems and, consequently, positive student learning outcomes, not just in South Africa but the world over. The Human Sciences Research Council (HSRC) reports that only 53% of South African grade nine science learners who participated in TIMSS 2011 were taught by teachers who had completed a degree [4]. The less qualified teachers are the less the prospect of effective science teaching taking place.

South Africa also has one of the highest indices of educational inequality in the world [5]. Understandably, the degree of educational inequality mirrors socio-economic inequalities in the broader society and thus a strong correlation exists with the Gini index of income inequality in which South Africa is only second to Chile internationally. In the midst of these inequalities schools, which are constitutionally mandated to redress or atone for these inequities in disadvantaged communities may actually carry the brunt of neglect as the quality of support they receive from their marginalized communities tends to be negligible. Given that the majority of learners come from disadvantaged state funded schools, it is not surprising that the national average quality of science and mathematics education falls dramatically short of international competitiveness by the World Economic Forum’s Global Competitiveness reports (e.g. [6]; [7]), where South Africa has consistently ranked poorly (144th out of 144 countries) and by international benchmark test standards (e.g. [8]; [9]) where South African learners ranked second worst testifying to the extent of educational inequality besetting the school system.

Participation in science fairs carries with it the potential to provide learners with experiences of high levels of inquiry science. It, however, transpires that successful participation does not only depend on the teacher efforts but also on the cultural
capital of the school and the individual learner. Teaching science in the traditional science classroom has characteristically meant that learners frequently sit listening passively or transcribing notes to commit to memory while teachers talk and chalk about the content, structure and results of scientific knowledge. This traditional orientation has been more dominant in under resourced schools suggesting the possibility that the authentic practical experience of the inquiry nature of science might be inadequate for many learners form marginalized communities. The Expo for Young Scientists, a science fair sponsored annually in 26 regions by the power utility ESKOM/ESCOM (Electricity Supply Commission), offers learners an opportunity to engage competitively in scientific investigations that are in keeping with the principles of scientific inquiry and curriculum requirements. Many studies indicate that hands-on activities such as science fair projects are central to the epistemology and appeal of science (e.g. [10]; [11]). In light of the potential the Expo offers, this study sought to explore some extraneous socio-economic factors influencing learner participation and success in the Expo and to make recommendations for future redress. Such an exploration is pertinent in initiating and sustaining social justice debate about levelling the uneven playing field. To accomplish that goal, the remainder of this paper first frames hands-on activities in science within scientific inquiry principles and then discusses [12]'s cultural reproduction theory as a possible explanatory framework for learners' ability to participate and to succeed in the Expo. Secondly the research questions are formulated and the methodology adopted for the study is elaborated upon. Thirdly, the results are presented, discussed and conclusions drawn, and recommendations made.

1.1 Levels of scientific inquiry

While [13] state that at its heart inquiry is an active learning process in which students answer research questions through data analysis they point out that the most authentic inquiry activities are those in which students answer their own questions through analysing data they collect independently. This is consistent with the problem-posing approach espoused by Freire (2000) and in full agreement with Albert Einstein’s belief that scientific knowledge grows most by virtue of the nature of the questions we ask. The superlative ‘most’ in the last but one sentence suggests the existence of levels of authenticity of scientific inquiry experiences. [13] affirm that an activity can still be inquiry based when the questions and data are provided, as
long as students are conducting the analysis and drawing their own conclusions. Building on the work of [14], [15] propose a hierarchy of four levels of inquiry activities, viz:

1.1.1 Level 1 - Confirmation activities
Students are provided the question and the procedure and the expected results are known in advance. For example laboratory experiments to verify results that are already known.

1.1.2 Level 2 – Structured inquiry activities
Students investigate a teacher-presented question through a prescribed procedure but results. Both level 1 and 2 are commonly referred to as ‘cookbook labs’ since they contain step by step instructions. The difference is that level 2 activities answer a research question or it can also be a matter of timing in that a Level 1 activity can become a Level 3 activity by presenting the experiment before teaching the target concept.

1.1.3 Level 3 – Guided inquiry activities
Students design or select the procedure to carry out the investigation. A teacher presented question features but the methods and solutions are left open to the students. Guided inquiry activities have the potential to take student engagement and ownership to a new level. However, the teacher still has to approve the procedures and ensure that proper safety precautions are taken before the investigation is carried out.

1.1.4 Level 4 – Open inquiry activities
Problems, solutions, and methods are left to the student and science fair projects are the most common form of level 4 inquiries.

The attainment of Level 4 activities assumes that students have had prior classroom experience with Levels 1-3 activities as stepping stones. That is, students cannot be expected to conduct high level inquiry investigations after having participated exclusively in low-level activities [13]. Accordingly students cannot be expected to participate successfully in Expo type projects unless they have a strong experiential foundation of scientific inquiry activities at all levels in their science classrooms. However, the quality of student participation may not just be a function of the quality
of instruction received but also by the quality of both in-school and out-of-school support infrastructure and systems available to a learner. This provides a rational for recourse to Bourdieu’s socio-cultural capital theory.

1.2 Bourdieu’s cultural capital theory

To avoid reducing the social world to a succession of spontaneous mechanical equilibriums between agents Bourdieu [12] proclaims the need to reintroduce the notion of capital, in all its forms, together with its accumulation and all its effect. He suggests that the structure of the distribution of the different types of capital and the various sub-types thereof at any given moment in time reflects the inherent structure of the social world. In other words the set of limitations and constraints manifest themselves in the very reality of that world, determining and defining the chances of success for practices such as effective preparation for science fair participation. Bourdieu [16] defines cultural capital loosely as ‘those cultural traits that help people to gain educational success’. In other words it is those cultural attributes or assets available to provide a learner with a competitive edge in educational attainment. Success in a science fair is an apt example in the context of this paper.

Bourdieu ([12]; [17]) contends that cultural capital or better still, informational capital can exist in three forms: in the embodied state (or long-lasting dispositions of the mind and body); in the objectified state or cultural goods (such as pictures, books, dictionaries, instruments, machines, etc.); and in the institutionalized state (such as educational qualifications). With reference to the embodied state, a learners’ home background, educational levels of his/her significant others contribute to and shape his/her attitude towards life and educational possibilities. With reference to the objectified state, the number of books (and latter day ICT gadgets such as computers, laptops, smartphones, and DStv) available at home has long been identified as a catalyst to a learner’s interest and curiosity in education and ultimately to academic achievement. With reference to the institutionalised state, the school a learner attends has long been acknowledged to be a major determinant of his/her chances of accessing higher education and good life ever after. Little wonder Bourdieu claims that the notion helped him to explain the unequal scholastic achievement of children from different social classes, i.e. the profits obtained by the children in the academic achievement market. In other words, success in modern
societies is facilitated by the possession of cultural capital and of higher-class habitus \(^2\) [16].

This theory suggests that students are distributed in the overall social space according to the volume of cultural capital they possess and according to the composition of their capital, i.e. the relative weight of the various forms of capital (economic, cultural, social and symbolic) [16]. Therefore students with higher accumulations of cultural capital in the form of educated parents, higher socio-economic status, attendance of elite schools, would appear to stand a better chance of success in educational endeavours. This includes first, participation in science fairs, and secondly participation with success. Bourdieu’s concept of cultural reproduction is epitomized when cultural success breeds educational success which in turn breeds cultural success. That is, according to Bourdieu’s theory of cultural reproduction, cultural resources associated with the middle-class home facilitate the acquisition of educational credentials [18] which underwrite success in life. The challenge is to determine the contribution that enhanced participation in the Expo can do to break this reproductive cycle? On the one hand we have some privileged school leaders who think that the Expo is for underprivileged schools while on the other hand we have some underprivileged school leaders who believe that the Expo is for privileged schools with resources. Whereas the school poverty quintile categorisation is an indicator of the socio-economic status of the school on a scale ranging from 1-5 from poorest to the least poor schools (e.g. [4]; [19]) and to that extent can serve as an indicator of accumulated cultural capital, it can be argued that the quintile system is not as a black and white classification system as it might appear to be. This study sought to debunk some of these myths.

2 RESEARCH QUESTIONS

The aim of this study was to explore some challenges or factors influencing Expo participation and success rate of learners from different school quintiles in order to make recommendations for future improvements. To achieve this aim the following research questions guided the study: What factors impacted the participation rate of schools? What factors impacted the success rate of schools?

\(^2\) Habitus is a set of attitudes and values held by the members of a social class [14].
3 METHODOLOGY

The methodology adopted for the study was a quantitative design. To address the research questions participation records for the 2010 regional expo were analysed in terms of school types (representative of the economic, cultural and social capital accumulations of learners) and the medals and special prizes won. The sample of participating schools was a total of 37 primary and secondary schools. The total number of learners who participated was 329 of whom 153 were juniors (grades 7-9) exhibiting 97 projects and 176 were seniors (grades 10-12) exhibiting 113 projects. Since all schools that participated were included in the analysis, this was a convenient sample. Of the 329 learners 112 were male and 217 were female. The total number of eligible schools was determined through a navigation of the Western Cape Education Department’s website according to district. The results of the participation and success rates were analysed statistically using the appropriate graphs, tables and indices. The spearman rank correlation coefficient was chosen because the schools were not normally distributed by virtue of being a convenient sample.

4 RESULTS

4.1 Analysis of the Expo participation rate of schools by type

In all, 37 schools participated in a region consisting of four districts with a total of 712 schools of all types. The overall participation rate was therefore a paltry 5.1% of all eligible schools\(^3\). Of the 37 schools that participated more than 50% of them were high schools, 19% were combined schools, 16% were intermediate schools, and 14% were primary schools. The intermediate and combined school entries were dominated by grades 7-9 (Senior Phase) and 10-12 (Further Education and Training) learners suggesting a bias towards secondary school learners in these schools. This bias was in keeping with the region’s emphasis. Figure 1 is a pie chart showing the proportion of schools that participated by type.

\(^3\) At the time of the study the Western Cape consisted of only two regions.
Table 1 shows the distribution of school participation by distance from the venue. Learners from some had to travel long distances by virtue of the rural nature of the districts that make up the region in this study.

Table 1: Participation rate by school distance from the venue

<table>
<thead>
<tr>
<th>Distance from venue</th>
<th>0&lt;d&lt;20</th>
<th>20&lt;d&lt;50</th>
<th>50&lt;d&lt;200</th>
<th>200&lt;d&lt;300</th>
<th>300&lt;d&lt;400</th>
<th>400&lt;d</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participating schools</td>
<td>6</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>37</td>
</tr>
</tbody>
</table>

For state funding purposes, South African schools are classified according to poverty quintiles as described above. More money is allocated to poorest schools and less is allocated to the least poor schools. The quintile score of a school is calculated based on the national census data for the school catchment area with respect to income, unemployment rate and level of education [19] which are plausible proxies for the socio-economic capital accumulated by the schools. Figure 2 shows participation of schools by poverty quintile levels 1-3 and 4-5. At 70.3% the least poor schools clearly dominated the participation rate.
Figure 2: Proportion of school participation by poverty quintile category

Figure 3 is a graphic illustration of the participation rates of learners by grade category (junior/senior) and school poverty quintile category and confirms the numerical dominance of learners from the quintiles 4-5 category. Although the least poor school participation rate stood at 70.3% the participation by number of learners and projects averaged 84% in both junior and senior categories. This meant that the majority of learners who participated in the regional expo in 2010 came from well-to-do schools.

4.2 Analysis of the Expo success rate of schools

The Expo awards were of two kinds: medals and special prizes. Judges awarded marks in three parts, Part A (maximum of 30 marks for written communication of the project as contained in the poster and the project file), Part B (maximum of 20 marks
for oral communication in the interview of the learner(s)) and Part C (maximum of 50 marks for the overall scientific and originality levels of the research investigation project). An exhibit was awarded a gold medal if it scored 80% or above, a silver medal for a score of 70-79% or a bronze medal for a score of 65-69%. Special prizes were awarded to best projects in categories sponsored by various not-for-profit organizations.

Overall the schools in the quintiles 1-3 category won 4 medals and two special prizes out of a total of 137 medals and special prizes awarded in the event. That is, schools in quintiles 1-3 although constituting 29.7% of the schools that participated (and 15.3% of the learners that took part) actually won only 4.4% of the medals and special prizes. Figure 4 graphically illustrates the success rate by medal or prize type and school poverty quintile category. Ninety-six percent of the gold medals, 97% of silver medals, 96% of bronze medals and 93% of special prizes were won by schools in quintiles 4-5. Only one gold medal was awarded to a school in the quintile 1-3 category out of eleven schools in this category. Ten out of 26 schools in the quintiles 4-5 category managed to win gold medals but 12 (7 plus 5) or nearly half of the gold medals were scooped by the two best schools in this quintile category. Sixteen of the schools in the quintiles 4-5 category did not win any gold medal.

![Figure 4: School success rate by medal type and school quintile category](image)

Furthermore, Table 2 shows the Spearman-rank correlations between the success rate of the school at the Expo and school fees levels, as well as between the number of computer laboratories and science laboratories.
The Spearman rank correlation coefficient measures the strength of a monotonic (non-decreasing) relationship between two paired (ordinal) data (http://www.statstutor.ac.uk/resources/uploaded/spearmans.pdf). The Spearman correlation coefficient as an effect size measure can be interpreted using the following guide for the absolute value of $r_s$: .00 – .19 very weak, .20 – .39 weak, .40 – .59 moderate, .60 – .79 strong and .80 – 1.0 very strong. The results thus suggested a strong positive correlation between the school income level and success at the Expo, and a strong correlation between the number of laboratories and the success rate at the Expo.

Table 2: Spearman-rank correlations for participating schools

<table>
<thead>
<tr>
<th>Variables of correlation</th>
<th>Value of $r_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation between success rate at the Expo and school income level</td>
<td>0.7</td>
</tr>
<tr>
<td>Correlation between success rate at the Expo and number of laboratories</td>
<td>0.6</td>
</tr>
</tbody>
</table>

5 DISCUSSION OF RESULTS

5.1 Socio-economic factors influencing the participation rate at the Expo

That only 5.1% of total eligible schools (or 17.3 % of high schools) participated in the Expo, suggested that the expo attracted a fairly exclusive club of schools. That only one percent of primary schools eligible attended, reflected the absence of emphasis in encouraging their participation although it could be a logistical challenge if all of them attended. That of those schools which participated 70.3% were in the quintiles 4-5 category suggested that participation in the Expo was largely by elite schools 'with the resources'. However, the extremely varied income levels of schools categorised to be in quintiles 4-5 (R220-R44500 per annum per learner) suggested that the allocation of some schools to this category could have created an illusion that they were well-resourced. Distance was a major deterrent, even though ten schools located more than 300 kilometres away from the venue managed to participate. They only managed to do so courtesy of corporate funding for the furthest district. Limitations imposed by distance could, however, be overcome by

4 1US$ = R12.30 as of 12 March 2015
decentralization of the preliminary rounds of the Expo to district level but more funding would have to be mobilized from the corporate sector. The participation of girls exceeded expectations as two in every three participating learners were female. A factor partly accounting for this unexpected distribution could have been the location of two quintile 5 girls high schools close to the venue and together accounting for close to 25% of the girl participants. By contrast, a quintile 5 high school for boys also located in the proximity of the venue opted to participate in another region.

5.2 Socio-economic factors influencing the quality of success at the Expo

The success rate as measured by the number (and type) of medals and special prizes won evidenced gaps in the quality of projects between school poverty quintile categories. That 26 schools in the quintiles 4-5 category between them won 96% of the prizes was evidenced the gaps in the quality of guidance learners received. However, not all so-called quintiles 4-5 schools produced high quality projects. More surprising though, was that about half the gold medals were won by two schools making it a non-contest for the eleven that did not win any medal at all. It is doubtful that winless schools will participate on a sustainable basis and this calls for more external support to increase chances of participation with success. On the surface of it though this suggested that some schools participated without adequate preparation to enhance their learners’ chances of success and teachers of such schools needed more support from the university organizers.

That school success rate correlated strongly with school income as measured by school fees levels (coefficient of 0.7) and the availability of infrastructure as measured by the student-to-laboratory ratio (coefficient of 0.6) suggested that schools which were under-resourced (with poorer socio-economic capital) stood a worse off chance of participating effectively in the Expo and a worse off chance of maintaining effective mathematics and science education on a routine basis.

6 CONCLUSION

The results of this study suggest that non-teacher factors that worked in favour of participation were school type, school distance from the venue and school poverty quintile. Factors that favoured success were largely school socio-economic status
(school poverty quintile) as a measure not only of the accumulated cultural capital of the learners but also accumulated economic and social capital (at school and at home). The poorer quality of projects produced by schools in the lower poverty quintile category suggested weaker school and out-of-school socio-cultural capital support systems. This study thus concurs fairly with [20]’s observation that township school learners find it difficult to compete at science fairs with learners who have laptops when they don’t have any themselves. Learners using bare hands science stand little chance of winning against well instrumented science learners. This study also appears to support the claim by [21] that South Africa’s education system is still predominantly a tale of two schools: one which is wealthy, functional and able to educate students, while the other is poor, dysfunctional, and struggling to equip students with the necessary skills they should be acquiring in school. The challenge is to balance the imbalances through sustainable redress and affirmative action mechanisms.

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