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Out-of-school Activity: A Comparison of the Experiences of Rural and Urban Participants in Science Fairs in the Limpopo Province, South Africa

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ABSTRACT

The paper compares the experiences of rural and urban learners who participate in Eskom Expo for Young Scientists science fairs in the Limpopo province of South Africa. Within an exploratory case study in the Limpopo province, a third-generation activity-theory framework was applied as an analytical tool to determine differences in activities between learners from rural and urban schools. To address triangulation, personal meaning mapping, interviews, focus-group discussions, and observations were used. The study involved eleven learners, six from rural schools and five from urban schools. Themes were identified to present the learners` view on science fairs and possible reasons for their performance or failure. The results revealed that the differences in activities of rural learners are due to: poor school facilities, lack of support, lack of mentors, lack of equipment, lack of computers and computer illiteracy. Two new areas are confirmed namely the level of attention with regards to learner`s engagement and readiness to learn and depth of knowledge of learners – factors that were not identified in previous studies on science fairs.

Keywords: activity theory, out-of-school activity, personal meaning mapping, science fair

INTRODUCTION

Some ethnic groups do not prefer pure sciences because to them they think they are for "white men" (Wong, 2015). However, out-of-school time programs such as science Olympiads, robotics and science fairs (Sahin, 2013) confirmed positive attitudes and achievements in science (Dabney, Chakraverty, & Tai, 2013). The out-of-school programs (Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt, 2011; Robelen, 2011) have supported scientific literacy and well-planned out-of-school programs are able to "foster interpersonal competence, help define life goals and promote educational success" (Wirt, 2011, p. 48). While the learners are doing these activities, they acquire scientific skills, and improve communication skills and content knowledge (Fisanick, 2010; Tran, 2011). Involving learners in STEM (Science, Technology, Engineering and Mathematics) related out-of-school activities help in building STEM interest in learners and they will likely take up STEM careers (Sahin, 2013). In addition, learners find solutions to daily-life challenges in out-of-school settings and they will be able to construct their own meanings (Cicek, 2012).

These out-of-school programs offer a way by which learners can join science fairs (Sahin, Ayar, & Adiguzel, 2014). Science fairs are events where learners' science projects are shown and judged for prizes (Merriam-Webster, 2016). However, the original idea of science fairs is to enable citizens of a country to understand science and its role in society (Flanagan, 2013). In South Africa, the best-known science fair is the science expo and called Eskom Expo for Young Scientists. The purpose of this Eskom Expo is to provide a platform for learners to gain valuable work experience, to connect high-achieving youth to innovators, to enrich their skills, to inspire them to explore their passions and become more knowledgeable on the topic they are studying (National Research Council, 2012).

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Contribution of this paper to the literature

- Learners embrace the use of scientific methods of research however their understanding is very shallow due to lack of readiness and engagement.
- Learners in especially developing countries do not perform well in international science fairs due to lack of parental and teacher support – teachers indicate that science fairs are extra work for them and not part of the school curriculum.
- Rural schools do not have computers and those with computers do not allow learners to use them as this is after school and the teachers do not want to stay.
- Learners are supposed to learn from each other especially during science fairs, this study reveals that learners' levels of attention are low and they are distracted and not focused when projects are displayed at regional level.
- This study aims to fill the gap in out-of-school paucity of literature in Africa and to understand how the Eskom Expo for Young Scientists program contributes in this space.

A significant number of teachers believe that science fairs could help learners to develop skills, attitudes, and knowledge leading to a career (Czerniak, 1996). Therefore, schools, parents and science mentors should provide a platform for learners to explore their interests in a less formal environment to enable innovation and creativity in STEM (Wagner, 2012). There is also research evidence that learners who participate in science fairs improve academically (Kahenge, 2013).

In South Africa, the science-fair competitions are done from school level, regional or provincial level and, finally, national level. The learners participate from grade 5 to grade 12. The learners with the best science projects from the provincial competitions will proceed to the national science fair, which is normally held in the first week of October each year. In order for a project to win a gold medal, it must score 80% and above, a silver medal 70–79% and a bronze medal 61–69% as judged by adjudicators. For the past three years (2014, 2015 and 2016) learners in Limpopo province have not won a single gold medal at the national science fair.

Therefore, this study has two aims. Firstly, to determine the factors influencing the performance of learners at science fairs, and more specifically in the Limpopo province of South Africa. Secondly, to determine if there are differences among learners from rural and urban schools in terms of the factors. Rural schools are the previously disadvantaged schools (PDIs); poor schools with limited resources and urban schools are well-resourced schools (Ndlovu, 2015; Taylor, 2015). The research questions for this study are:

1. What are the issues influencing the activities of learners at science fairs in the Limpopo province of South Africa?
2. What are the differences among learners from rural and urban schools in terms of these issues?

THEORETICAL FRAMEWORK

Activity theory, initiated by Lev Vygotsky, is a philosophical framework used to study human activity, practices and actions (Barab et al., 2002). Activity theory has been modified by having the two interacting activity systems with interacting objects to give rise to the third object (see **Figure 2**) and thereby to the third-generation activity theory, as it includes the interconnecting of individuals and the community as an analytical tool. This tool was chosen, firstly to analyze the factors which make up the components of activity and, secondly, to compare the two groups of participants, rural and urban learners.

Activity theory describes a triangular structure with six interdependent and related components (see **Figure 1**)

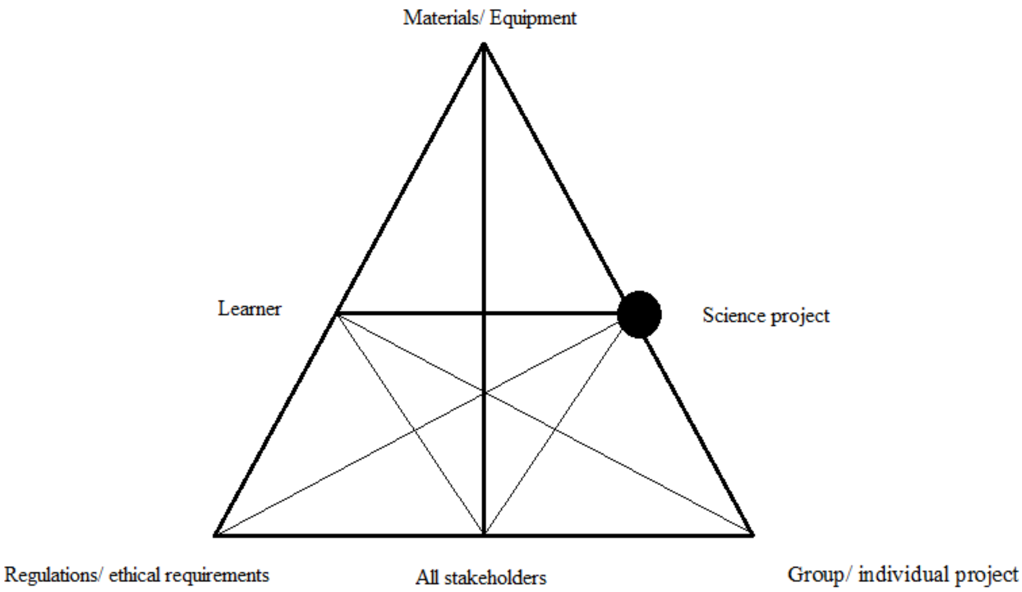

Figure 1. Science-fair diagram in terms of this study (figure done by the researcher)

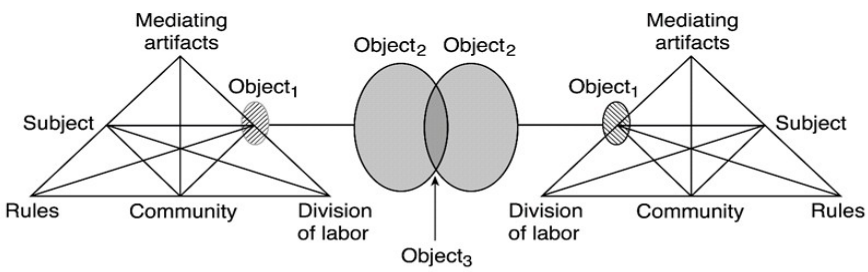

Figure 2. Two interacting activity systems with shared object as model for the third generation of activity theory (Engeström, 2001, p. 136)

The newly appeared 'third object' gives rise to a driving force for the transformation of the original activity system by means of feedback to the respective activity system, in this study the rural and urban learners.

The various components of the activity triangle (Engeström, 1987) are described below in terms of how it is implemented in this study:

The **object**	the purpose of the activity is the EE science fair, the school-based science fair (object 1) is improved to the regional science fair (object 2) which is later upgraded to the international science fair (object 3).
The **subject**	the individual actors in this study are the participating learners.
The **community**	the combination of all actors; in this study, the community refers to all stakeholders namely the learners, teachers, school administrators, department of education officials, science-fair personnel, judges, mentors, and parents.
The **tools**	the artifacts are what the learners, in producing their science projects, use; for example, laboratory equipment, materials, documents, etc.
The **division of labor**	refers to how the research projects are carried out; if it is a group project it must be clear who does what and using what.
The **rules**	all science-fair regulations and ethical requirements.
The **outcome**	this is the outcome of learner activity, the final research project and it also includes the result of the science-fair adjudication.

According to the activity-theory framework, learners' science projects are to be taken as tools and have a mediating role between the outcome and the learner in the activity systems of research work (see **Figure 2**).

Table 1. Distribution of the sample

School location	Total number of learners	Primary school	Secondary school
Rural	6	2 females (both in grade 7)	2 males (grades 11 and 12) 2 females (grades 11 and 12)
Urban	5	2 females (in grade 6 and 7)	1 female (grade 10) 2 males (grades 10 and 11)

METHODOLOGY

To gain an insider view (Creswell, 2014) of the factors influencing the performance of learners, constructivism and the interpretivist paradigm was taken as point of departure. An exploratory case-study research design was followed. An inductive analysis, which is the identification of patterns and themes in the data, was applied (Bertram & Christiansen, 2015; Creswell, 2014; Leedy & Ormrod, 2010; Nieuwenhuis, 2010). The information collected provided insight into the learners' view on science fairs and possible reasons for their performance or failure.

Sampling

The sampling was purposeful and participants for this study were drawn from the four Eskom Expo districts of Limpopo province. A simple random selection procedure using project category numbers was utilized to select participating schools. The selected sample consisted of 11 learners (six from rural schools and five from urban schools) distributed in different grades taken from the regional science expo finalists (see **Table 1**).

The Instruments

Activity theory is used as lens to collect and evaluate data to answer the research questions. Therefore, the instruments used to collect data were, personal meaning mappings (PMMs), interviews, focus-group discussions (FGDs) and an observation protocol. The PMMs, interviews and FGDs collect information on what the learners' view is on the EE science fair and possible reasons for their performance or failure. This will inform the activity-theory components; learners, materials and equipment, stakeholders and science project. The observation protocol was used to get information and to see if it was a group project or an individual project (division of labor). Permission letters to conduct research were obtained from the department of education, Eskom Expo for Young Scientists and from the school principals.

Personal Meaning Mapping (PMM) and Interviews

Personal Meaning Mapping (PMM) was originally developed for museums, festivals or similar events in order to understand the experiences and knowledge of visitors or participants (Adams, Falk, & Dierking, 2003). Since then, PMMs have been used by proving a reliable instrument for learning assessment (Falk, Moussouri, & Coulson, 1998). For example, Lelliot (2014) used PMMs to understand how participants learn about gravity.

According to van Winkle and Falk, (2015) PMM is used by providing the participants with a blank paper on which a word, name or phrase is written at the middle of the page. They are then required to write around the phrase or word in the middle whatever comes to their minds. The researcher collects the papers and the participants are then interviewed based on what is written on the papers. After the experience or in the case of this study, after the science fair the participant is given back the paper to add more information using a different colour of ink. The interview is done again based on the changes made to the PMM. This enables the researcher to track changes in knowledge or attitudes of participants before and after the science fair.

The researcher used PMMs and follow-up interviews as a qualitative tool to have a better understanding of the learners' view on the EE science fair in general before and after the regional science fair. Therefore, the PMM provides a platform for learners to communicate their science-fair experiences, yielding descriptive qualitative data (Leftwich, 2012), and this provides a methodological tool to evaluate themselves in terms of type of experience and depth of knowledge.

Focus-Group Discussion (FGD) Protocol

To elicit what learners' views are on the factors influencing their performance or failure in the science fair, eight questions were used as guideline, namely:

What are the reasons according to you for poor performance in science fairs?

What do you think is the expectations to achieve well from your school?

Table 2. Observation protocol

Activity name or summary	Observer comments
Learner distracted	
Learner focused	
Learner engaged	
Enthusiastic during judge interviews	
Self-confidence and body language	
Learner demonstrate understanding of his project in terms of content	
File and displays neatly and well organized	
Regulations and ethical issues	
Division of labor	

What are your views on your teachers` involvement with your research project?

What form of assistance do you expect from your school?

What would you expect your parents/guardian to do for you in order to assist you with your science project?

What are your views on the science-fair judges?

Do you understand the scientific method of doing a research project?

What should be improved on science fairs?

The FGD protocol was piloted with a group of five learners who were not part of the group under study. These students had to indicate any unclear questions that needs to be changed. There were 2 focus groups selected randomly from the 11 participants.

Observation Protocol

An observation protocol was set up in terms of the level of attention shown by the participants throughout the science-fair activities. This was important as it could offer evidence on the focus and engagement of the learners during the science fair. Focused and engaged learners learn from other learners' best practices as well as from the judges, parents' and other stakeholders' positive comments. In addition, learner behaviors and activities in terms of interaction with other exhibitors, and, for example, the reading of display boards of other participating learners were noted. The last 5 aspects of the observation protocol were included because they are also part of the judges' assessment criteria. The observation protocol used is shown on **Table 2**.

DATA COLLECTION AND ANALYSIS

The learners completed their PMMs before and after the regional science fair and the answers to the FGDs were captured on a voice recorder. The researcher and two other volunteers completed the observation protocol. In order to ensure consistency an observation guide was used which indicated what was to be observed. In addition, the observers were trained and a pilot test observation was done. After the pilot, they discussed their notes noting that there were not significant differences in their interpretation.

Data Analysis of the PPM

The analyses of the PMMs were done both within and across participants (Bertram & Christiansen, 2015). Based on the researcher's experience the two categories – types of experience and depth of knowledge – where chosen in order to possibly extract factors that differentiate the urban and rural learners with regards to their performance at science fairs.

The learners' PMMs in terms of types of experience was analyzed using the four dimensions; object experience, cognitive experiences, introspective experiences and social experiences (Pekarik, Doering, & Karns, 1999). For example, object experiences entail "seeing "the real thing", while cognitive experiences describe the gaining of information or knowledge. The introspective experiences include imagining different places and times, and social experiences and entail the time spent with friends, family and include conversation with peers, teachers and others.

The learners' PMMs in terms of the depth of knowledge was analyzed based on the four-level categorization: recall, concept, strategic thinking and extended thinking (Webb, Alt, Ely, & Vesperman, 2005). These four categories are important in that they expose areas of weaknesses or strengths to the activities of learners. For example, urban learners exhibited high levels of strategic thinking as compared to rural learners.

Table 3. Dimensions for PMMs

Dimensions	Rural learners	Urban learners
object experience	80% of the learners do not understand the scientific methods of conducting a research and writing the report.	20% of the learners do not understand scientific methods of conducting a research project.
cognitive experiences	Not able to display higher level of thinking and planning using evidence	Showed no evidence of complex reasoning.
introspective experiences	Inspiring, encouraged to dream big, motivated, more confident.	Encouraged to become a scientist.
social experiences	Making friends, getting public opinion on their science project. Felt ashamed of poorly done project.	It's fun and cool, opportunities, making new friends, sharing information.

Data Analysis of the Interviews

PMM was a qualitative tool that allowed the participants to express the knowledge and diverse meanings they on the science fairs. Learners were questioned on their understanding of science fairs in the semi-structured interview and further probing was followed in order to understand their responses.

Data Analysis of the Observation Protocol

The levels of attention of the learners were evaluated by using the following categories: distraction, focus and engagement (Bitgood, 2010). Their engagement was analyzed by observing the learners' behaviors and activities in terms of how they interacted with other exhibitors and reading display boards of other participants. The observers looked into how the components of the activity triangle were interacting, namely; the materials/equipment, learners, ethical issues, stakeholders' division of labor and science projects.

Data Analysis of the FGDs

The FGDs collected information on what the learners view is on the EE science fair and possible reasons for their performance or failure. This informed the activity-theory components: learners, materials and equipment, stakeholders and science project. As the FGDs provided information on what the learners' view is on the science fair and possible reasons for their performance, it was analysed in terms of the activity-theory components. The learners used materials and equipment for their science project. Thematic analysis was done by examining and recording the patterns across the collected data. The researcher identified constructs during and after data collection by analysis of words that is key-words in contexts and most repeated words or phrases. Therefore, by analyzing the FGDs thematically (Mayring, 2014; Seidman, 2012) it would not only give the science-fair organizers specific details on what influences the learners' performances at science fairs to make informed decisions about current and future science fairs but also inform the other stakeholders.

The FGDs were video-recorded and provided information on what the learners' view is on the science fair and possible reasons for their performance as it was analyzed in terms of the science-fair components. Transcriptions of the recordings were made. The learners freely gave information on the assistance they receive from their school or parents; "my parents were unable to buy for me the materials I needed for my science project so I had to change my initial project." Another learner from an urban school commented that "at our school there is a computer laboratory and we are allowed to use the computers for our research."

The researcher relied on detailed notes taken during the FGDs, and also replayed the videotape as needed. The nature of the analyses of FGD data was determined by the research questions of this study. There were two focus groups, the comments were rearranged to have answers together for each question. The researcher noted the main ideas in the answers and identified themes.

RESULTS

Personal Meaning Mapping (PMM)

Type of experience with regards to learner`s engagement and readiness to learn.

An example of a PMM to illustrate the type of experience this learner had with the regional science fair (see **Figure 3**). The learners used red ink to write the PMM before the science fair and later they wrote in black ink.

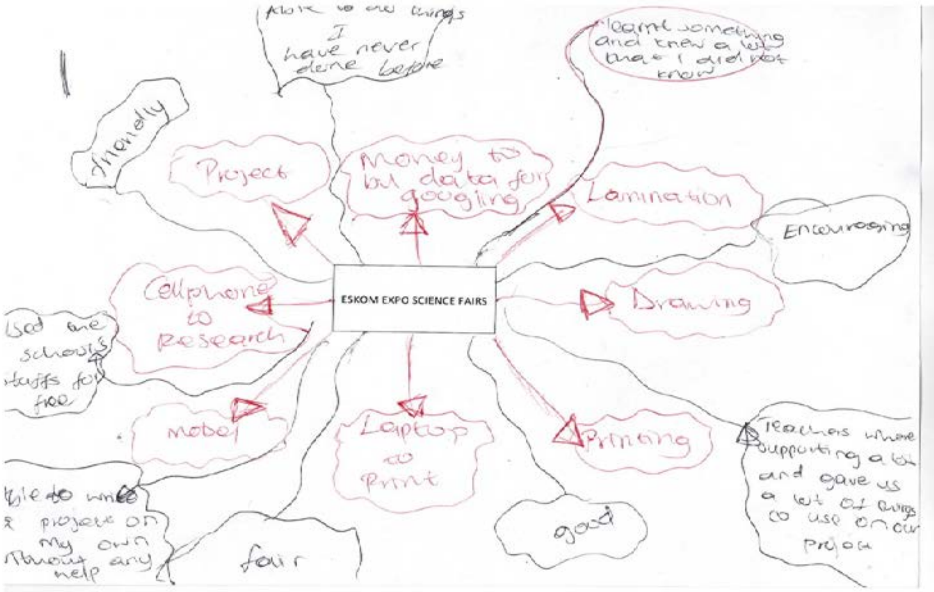

Figure 3. Example of a PMM of a learner to illustrate his type of experience

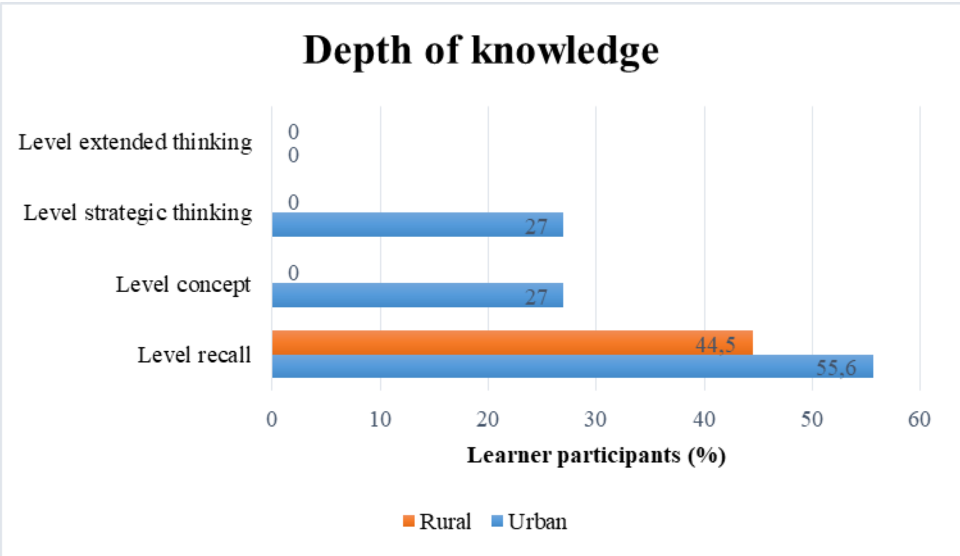

Figure 4. Depth of knowledge of learners

Each of the learners' experiences were analyzed using the four dimensions. The urban and rural learners' experiences are presented (see **Table 6**).

Observations were done by looking at the level of attention using the three categories (see **Table 4**) formulated by Bitgood (2010).

Depth of knowledge

The rural and urban learners are compared in terms of their depth of knowledge in order to understand their scientific research skills, innovativeness and creativity. Each of the learners' depth of knowledge were analyzed using the four-level categories (see **Figure 4**).

From the results, it is evident that both our rural and urban learners' level of extended thinking is nonexistent. As for the rural learners, they lack strategic thinking as compared to the urban learners.

Table 4. The level of attention with regards to learner`s engagement and readiness to learn

Level of attention	Indicators
Distraction	Of the 11 learners under study, four learners (36,4%); three from rural school and one from an urban school, were distracted, not involved, they were talking, outside most times, and appeared to have a carefree attitude and playful.
Focus	Five learners (45, 5%); three from urban schools and two from rural schools were seen looking at other science projects in passing.
Engagement	Only two learners (18%) from urban schools were observed reading other displays and asking other learners, and teachers, or judges.

Table 5. Categories and Themes

THEMES	Theme 1 Communication	
	Theme 2 Support and assistance	
	Theme 3 equipment and computers	
Category 1	**Category 2**	**Category 3**
Community	**Tools**	**Division of labour**
learners	scientific skills	individual projects
teachers	cognitive experience	group projects
schools	introspective experience	
judges		
parents	social experiences	

The interviews

The interviews were used to confirm the findings from the PMMs and to get more clarity on the participants' meaning mappings. The outstanding ideas and themes were incorporated in **Table 4**.

Focus-Group Discussions (FGDs)

Three themes emerged from the analysis of the FGDs, namely communication, support and assistance, equipment and computers. Rural learners said they were not getting information about science fairs on time and that support they get from their school, teachers and parents is minimum. Unlike rural learners, urban learners enjoy a lot of support and their schools have equipment and computers, which they use for their research. Categories and themes where formulated from the collected data and arranged (see **Table 5**).

DISCUSSION

The purpose of this study was to identify the factors influencing the performance of learners at science-fair competitions in the Limpopo province and determine what the differences in performances are among learners from rural and urban schools.

The qualitative data from the FGDs, PMMs and the observation protocol were triangulated in order to validate results due to the small sample size. A third-generation activity-theory lens was used to interpret the data accordingly.

Data across all the three instruments indicate that the main reasons for performance of learners are as summarized on **Table 6**.

Table 6. A comparison of the activities of rural and urban learners

	Rural learners	Urban learners
Object	**Regional Science fair**	**Regional Science fair**
Subject	**Six learners**	**Five learners**
	Community	
Learners	Lack of needed materials and equipment, computers and printers, computer illiteracy among teachers and learners. Learners do not get information about science fairs on time. A significant number of rural learners were distracted and not focused during the fair. The depth of knowledge was significant on recalling of concepts but no evidence of strategic thinking and extended thinking during FGDs.	The schools have equipment. They get information from expo on time. Majority of learners were engaged during fairs Depths of knowledge evident on level of recall, concept and strategic thinking but absent on level of extended thinking.
Teachers	Lack research skills and confidence and are unable to assist the learners fully. Teachers indicate to learners that its extra work for them and it's not part of the school curriculum.	Teachers indicate to learners that its extra work for them and that it's not part of the school curriculum.
School	Not very supportive and they do not give them prime time and dedicated rooms to do their work where they are not disturbed by other learners. No computers and laboratory equipment.	Some schools have computers but the learners are not allowed to use them.
Judges	Students view the judges to be incompetent and lack interest during judging, not friendly, harsh or rude, overly critical, they don't answer learners\` questions. Judges are biased and favoritism is rife. Due to perceived lack of competence in the field their judging, they fail to offer constructive criticism.	Students perceive judges as lacking competence in the field their judging, thereby fail to offer constructive criticism. Lack competence and interest
Parents	Not very supportive in terms of finances, motivating and providing materials needed for the project. Some learners do not stay with their parents.	Parents are supportive. Some learners do not stay with their parents.
	Tools	
Object experience	80% of the learners do not understand the scientific methods of conducting a research and writing the report.	20% of the learners o not understand scientific methods of conducting a research project.
Cognitive experience	Not able to display higher level of thinking and planning using evidence, no evidence of complex reasoning during FGDs.	Showed no evidence of complex reasoning. Learners say that the experience has expanded their knowledge of physics.
Introspective experiences	Inspiring, encouraged to dream big, motivated, more confident.	Encouraged to become a scientist,
Social experiences	Fun, receive awards, making friends, getting public opinion on my science project. Felt ashamed with my poorly done project.	It's fun and cool, opportunities, making new friends, sharing information, asking questions to scientists.
Division of labor	A maximum of two learners per project, this ensures that all are active participants.	A maximum of two learners per project
Rules	Eskom Expo science-fair regulations.	Eskom Expo science-fair regulations
Outcomes regional science fair	Gold: 1	3
	Silver: 2	2
	Bronze: 3	0

The differences in learners\` views towards science fairs between learners from rural schools and those from urban schools:

a. Learners in the majority of rural schools indicate that they are not supported by the school, teachers and parents.
b. The communication of information about science fairs does not get to the rural schools on time.
c. The urban learners' views science fairs as a link to becoming a scientist, meeting scientists and making new friends.

The lack of resources has been documented as disadvantaging learners (Flanagan, 2013; Gifford & Wiygul, 1992; Mbowane, Villiers & Braun, 2017). The results of this study concur with previous studies that the poor quality of judges affects their competence and that some judges are biased (Atkins, 2014; Bernard, 2011). The findings in this study show that teachers and parents are not supporting learners and these findings are consistent with previous studies (Betts, 2014; Finnerty, 2013; Kahenge, 2013; Naidoo-Swettenham, 2017). This study has further introduced the aspects of level of attention and depth of knowledge of learners, which provided more insight into why learners fail to perform at science fairs.

With regards to the activity theory, all the facets of the activity triangle are interactive and interdependent giving rise to the science project. The quality of the science project is dependent on the contribution and positive interaction between these facets and stakeholders.

SUMMARY AND CONCLUSION

The overall findings of this study show that while learners embraced the use of scientific methods of research, their understanding of the same is very shallow because they lacked readiness and engagement. Learners in the Limpopo province perform poorly in the international science fairs because they lack parental and teacher support; schools do not have computers and those with computers do not allowed learners to use them. Teachers indicate to learners that science fairs are extra work for them and are not part of the school curriculum. The learners view the judges at science fairs as incompetent and biased; hence poor-quality projects are allowed to sail through to national competitions. The learners are supposed to learn from each other during science fairs; this study has revealed that learners' levels of attention are too low and they are distracted and not focused during the science fair at regional level. The knowledge of challenges faced by rural and urban science participants will help all stakeholders to assist the learners leading to their gaining of lifelong skills. The science fairs could contribute to giving learners the skills and knowledge they need to have to be successful in their studies and in life by imparting them with technological literacy, transformative skills, problem-solving skills and critical-thinking skills.

As a way forward, the schools should make use of past successful science-fair participants to work with their learners and to motivate others sharing their practices. Science clubs could be established in schools giving a platform for learners to show and practice their innovativeness and creativity. Learners should not work in isolation, parents and teachers and science-fair organizers should work together not only to develop scientific knowledge but also to reflect on their work as well as for the advantages of social learning.

FUTURE STUDIES

For future studies, this paper draws attention to three areas that could be investigated. Firstly, to investigate the effect of computer literacy and availability of computers with the carrying out of science fair projects. Secondly, to increase literature on the teachers' views and conceptions on science fairs since they are the ones mostly assisting the learners and finally to replicate this study in all provinces of South Africa.

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