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MEASURING INQUIRY ABILITIES OF YOUNG LEARNERS USING A PERFORMANCE-BASED ASSESSMENT

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Abstract

Scientific inquiry abilities and the nature of scientific inquiry (NOSI) are critical in building a scientifically literate citizenry. However, little information is available regarding the inquiry abilities of young learners between the ages of 5-7 years, though it is widely agreed that children are born inquirers. Among the reasons why inquiry abilities in young children are not explored is the need for reliable research instruments to measure these abilities. Most existing research excludes the measurement of young learners' inquiry abilities but tends to report more on the inquiry abilities of middle and high school learners. This study aims to adapt an existing performance-based assessment (PBA) and apply it in measuring the inquiry abilities of young learners aged 5 to 7 years in the South African context. The study aims to report on learners' innate abilities that develop naturally without formal instruction at kindergarten (grade R) and early primary to inform early science interventions. Three Afrikaans schools were conveniently selected as samples. Afrikaans is one of eleven official languages spoken in South Africa, and with no existing literature on Afrikaans learners' inquiry abilities in the foundation phase, a gap was explored. Data for the study was qualitatively gathered from 120 foundation phase learners (pre-schoolers to third graders) through an orally presented Performance-based Assessment of Kindergarteners' Scientific Inquiry Abilities (PAKSIA). Audio-recorded oral assessments were transcribed and translated into English. Transcripts were then scored using an adapted rubric to generate numerical scores on learners' performance. The numerical data were then analysed to provide descriptive statistics of participants' inquiry abilities. Of the four inquiry abilities assessed, high scores were realised in the experimentation and observation abilities. The results suggested that young learners have innate abilities to engage in inquiry activities. A multisensory and "play" approach to the adapted PAKSIA supported learners' engagement with tasks using their senses. Younger learners aged 5 and 6 struggled with more abstract questions, such as predicting or measuring without a measuring instrument. However, learners aged 7 displayed adequate abilities to predict, plan, design, investigate and communicate their results. The PAKSIA is a baseline assessment for educators to identify what inquiry abilities need more implicit nurturing and development. Some implications and recommendations for foundation phase learning are also made herein.

Keywords: *Inquiry abilities, performance-based assessment, foundation phase, scientific literacy.*

1. Introduction and background

One of the fundamental goals of science education is to help learners become scientifically literate and be able to contribute to and make informed societal decisions (National Research Council [NRC], 2000). As scientific literacy became essential to communities worldwide, scientific inquiry abilities became more relevant in the 21st century. The development of inquiry abilities can be viewed as a vehicle to promote scientific literacy within education sectors. Scientific inquiry abilities are skills to investigate and explore the natural world (Deboer, 2006). Learners who engage in inquiry display their ability to explore, question, plan, investigate, predict, provide accurate interpretations of findings, and communicate. These essential competencies assist people in participating productively within scientifically literate societies (Kuo et al., 2015). The study of inquiry abilities is familiar and has been going on for many years since the early 19th century (Deboer, 2006). However, focusing on measuring the scientific inquiry abilities of young learners is recent and needs further investigation. This study aimed to adapt an existing performance-based assessment (PBA) and apply it in measuring the inquiry

abilities of young learners aged 5 to 7 years in the South African context by answering the following research question:

Which scientific inquiry abilities are prominent in young learners ages 5-7?

To answer this research question, the following objectives were set:

- Administer an adapted PBA (the PAKSIA) to the selected group of learners.
- Score and analyse the PAKSIA for inquiry ability clusters.
- Report any observed differences and trends in young learners' inquiry abilities.

Six inquiry abilities were assessed: exploring, questioning, predicting, planning, designing, investigating, and communicating.

2. Literature review

Studies that developed instruments to measure young learners' scientific inquiry abilities have focussed on developing measurements with a holistic approach (Koerber & Osterhaus, 2019; Marian & Jackson, 2017). This may be because young learners do not receive formal science education at a young age but rather a broad exposure to science and the natural world. Some studies speculate about the abilities of young learners to conduct/engage in inquiry. However, results by Koerber & Osterhaus (2019) contradict these statements somewhat. Measuring the inquiry abilities of young learners using a performance-based assessment can be a useful tool to evaluate their scientific inquiry abilities. Performance-based assessments allow students to demonstrate their understanding of a particular concept or skill by completing a task or solving a problem (cite). It is challenging to assess young learners with traditional methods such as paper-and-pencil tests since they cannot read or write well or merely oral tests since their verbal can be limited. The PAKSIA instrument validated and proposed by (cited) was adapted to the South African context. Resources relevant to the participants were used, and questions were altered to fit the context. Although scientific inquiry abilities are interwoven within the basic education curriculum in South Africa, a gap exists with reliable research instruments to measure inquiry ability skills in young learners from kindergarten (grade R) to third grade in the Foundation phase. Furthermore, there is no assessment for inquiry abilities suitable for Afrikaans learners in South Africa.

In South Africa, the National Curriculum Statement (NCS) for Grades R-12 reflects the value of inquiry in the curriculum, aiming to produce "learners that can collect, analyse, organise and critically evaluate information" (Department of Basic Education [DBE], 2011, p. 5). The South African Foundation phase curriculum emphasises the importance of inquiry abilities. However, very few assessments of inquiry abilities have been constructed, and there are no explicit guidelines or policies regarding the measurements teachers can use to measure inquiry abilities. The unavailability of reliable research instruments to measure these abilities is why inquiry abilities in young children are not explored. Most existing research excludes the measurement of young learners' inquiry abilities. Still, it tends to report more on the inquiry abilities of middle and high school learners, which is why this study was timely. Some research reported findings of young learners displaying inquiry abilities from a young age (Chen, Wu & Hsin, 2022).

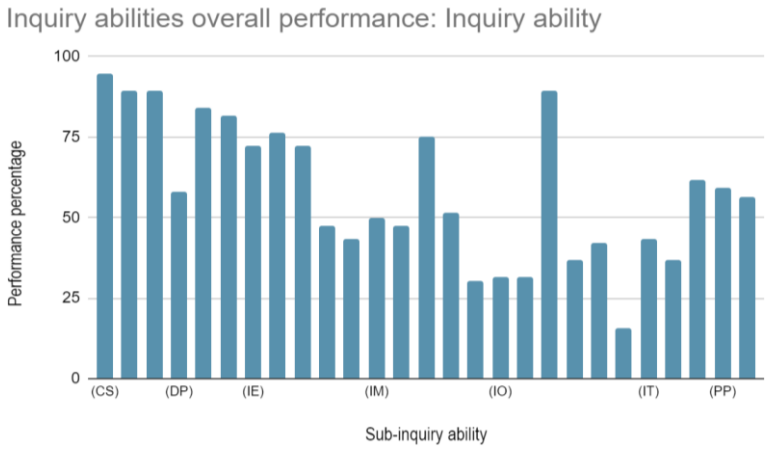
3. Methods

A descriptive qualitative research methodology was employed to determine the validity of the PAKSIA and the inquiry abilities of Grade RR (equivalent to pre-kindergarten) to Grade 1 learners. Data were collected from 40 learners (pre-schoolers and foundation phase learners) through a hands-on and orally presented Performance-based Assessment of Kindergarteners' Scientific Inquiry Abilities (PAKSIA). The oral assessments were conducted individually and with the first author and some trained peer teachers. The recordings obtained from the assessment were transcribed and back translated from Afrikaans to English for analysis and scoring. The transcripts were then scored using an adapted rubric to generate numerical scores on learners' performance. The numerical data were then analysed using MS Excel for baseline descriptive statistics on young learners' inquiry abilities.

4. Data analysis and results

Questioning and exploring tasks were further excluded from the six inquiry abilities assessed due to time constraints. Four inquiry abilities and their sub-abilities were assessed according to the Children Inquiry Ability Framework (Chen et al., 2022): *predicting* (Make predictions- PP), *planning* (Make a plan- DP), *investigating* (Making systematic observations- IO), (Employing tools- IT), (Measuring- IM), (Experimenting- IE) and *communicating* (Sharing- CS). Of the 120 participants, data obtained from 40 participant learners were scored and analysed to obtain the following descriptive results for this baseline report.

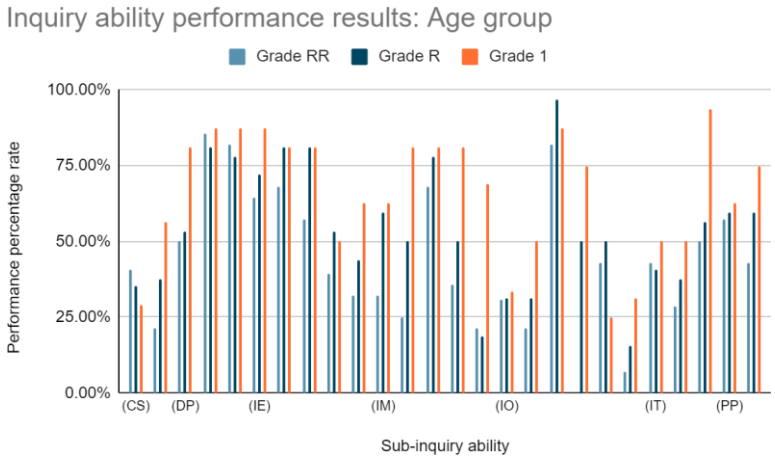
Figure 1. Overall observation of inquiry abilities.



As seen in Figure 1, high inquiry ability scores were realised in sharing (CS), with averages ranging from 89%, 89% and 74% on three questions in the PBA. Experimenting (IE) abilities followed with averages of 76%, 72% and 72% and predicting (PP) abilities in general, with performance averages of 59% and 56%. Learners performed poorly in measuring (IM), making systematic observations (IO), and employing equipment and tools (IT). Most systematic observation questions required abstract or higher-level thinking, and the results were generally poor (IO, 15%, 31%, 36%, 42%). Results were overall consistent in predicting abilities (PP, 59%, 56%).

Learners engaged actively with the presented objects to answer the questions. Evidently, some learners displayed flexible thinking when they adapted their incorrect answers after engaging with the materials. When choosing and predicting certain experiments, learners only choose the materials that fit their description or prediction of the outcome. Many learners did not display a complete innate understanding of dependent and independent variables. Some learners chose materials impulsively. They would state, for example, that they have the same car at home or like the colour blue, which is why they chose certain objects to experiment with. However, this was not the case for all the participants. It was evident that learners relate unknown situations with personal experiences to make sense of the problem. Misconceptions of science became clear in the data as learners predicted and chose suitable objects to experiment with. Some young learners, for example, chose all the small blocks in an experiment where the objects that would float should be selected. Learners predicted and explained that all the small objects would float because they are lighter than the larger blocks. A few learners changed their predictions as soon as they picked the objects up and could feel some were heavy and the metal blocks were cold. Although questioning was not assessed in the PBA, it was evident that learners used their senses and ask questions to further their understanding of the problem at hand. Figure 2 below shows the variation in inquiry abilities of the different age groups.

Figure 2. Differences in age group inquiry abilities.



From Figure 2, younger learners aged 5 struggled with questions that required developed language skills and abstract thinking, such as sharing (CS, 40%), measuring (IM, 35%), and making

systematic observations (IO, 42%). However, learners aged 6 displayed adequate abilities to predict (PP, 59%), plan (DP, 81%) and investigate (IE, 81%). Older learners in grade 1 performed better with most of the inquiry abilities than younger learners in Grades RR and Grade R: (CS, 56%) (DP, 87%) (IE, 87) (IM, 81%) (IO, 87%) (IT, 93%) (PP, 75%). Communicating and sharing results (CS, 40%, 25%, 29%) with measurement (IM, 21%, 18%, 68%) were some of the more difficult abilities to access on average. Standardised measurements are only introduced in late grade 1 and formally in grade 2. Most learners display inquiry abilities to some degree and show that young learners are born inquires with innate abilities. Learners changed their answers on multiple occasions when they used their senses, such as touch, to feel the weight of the instruments during a comparison.

5. Discussions and conclusion

Although abilities vary across age groups, young learners display innate abilities to be inquirers with few interventions received from formal education. It is evident from the data that measuring activities with standardised items and activities that require more abstract thinking and communication skills is difficult for most young learners. Using their senses to make sense of their environment, young learners can use inquiry abilities to solve problems. A multisensory and "play" approach supported young learners to engage in fun ways with tasks and to access answers while using their senses. The performance-based assessment allowed learners in Grades RR, R and 1 to engage in low-anxiety activities and showcase the most suitable skills to solve problems. The adapted PAKSIA performance-based assessment was a useful diagnostic tool for measuring young learners' inquiry abilities and can provide valuable insights into diagnostic assessments for scientific inquiry skills. The study is limited by the size of the participants. More in terms of a larger-scale inquiry is yet to be done to provide deeper insights into young learners' inquiry abilities in the South African context.

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