

# GRADE R TEACHERS' AWARENESS OF THE DEVELOPMENT OF SCIENCE PROCESS SKILLS IN CHILDREN

**Rolandi Minnaar**  
University of Johannesburg  
South Africa  
[rolandiminnaar@yahoo.com](mailto:rolandiminnaar@yahoo.com)

**Francois Naude**  
University of Johannesburg  
South Africa  
[francoisn@uj.co.za](mailto:francoisn@uj.co.za)

**ABSTRACT**– This paper takes the position that young children can benefit from early advancement of their science knowledge and that teachers need to be aware that children are ready to learn science in Grade R by way of developing their skills in thinking about and of ‘doing’ and experiencing science. We propose that teachers can do much to help children to change their naïve concepts and begin to form more advanced scientific concepts. The proviso is, however, that teachers have to be aware of children’s skillfulness at this age – their emergent, developmental ability to see and to experience the world scientifically. The findings showed that grade R is fundamental and develops the foundation for future learning, yet no form of formal science teaching occurs during daily activities or preparation to develop science process skills for future schooling was identified in the sample of six grade R teachers. Furthermore, effective teaching of concepts are inhibited by classroom management and learning challenges.

**Keywords:** Science Process Skills, Concept development, Science education, Childhood Education, Foundation phase.

## 1. INTRODUCING SCIENCE TO CHILDREN

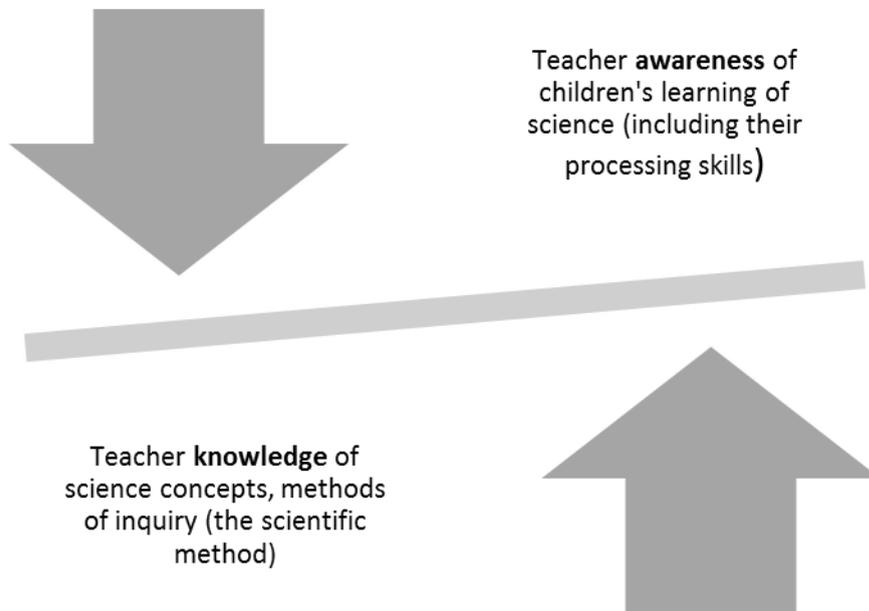
Young children, like adults, live in a world where scientific knowledge plays a central role. Research that argues for the importance of science literacy and the need to apply it to daily life has been reported often (Dökmea & Aydiline, 2009; Baird & Borich, 1987; Roth & Roychoudhury, 1993; Germann & Aram, 1996). Many everyday activities can be analysed for their natural science characteristics. Examples are gardening, cooking, recycling, map reading, comprehending the daily weather, inventing drugs for healing, or writing a computer program. Dehaene (2014:22), a cognitive neuroscientist, makes the observation about how scientific thinking refines language meaning: “Science often progresses by carving out new distinctions that refine the fuzzy categories of natural language.” In order to understand vague and difficult concepts, or what Dehaene refers to as “fuzzy categories of natural language,” knowledge of scientific facts and theories can be a catalyst for understanding the world and acting upon it. Westermann and Mareschal (2013) hold a similar view. Yet, many children in South Africa do not encounter science instruction in the early grades, possibly because the curriculum limits science learning to only one of the ‘Life Skills’ topics in the curriculum and teachers seem to minimise early science learning opportunities. Many children in the foundation phase continue to utilise their early (naïve) conceptions of science phenomena and do not learn to see and experience their world scientifically.

## 2. BACKGROUND AND MOTIVATION FOR THIS STUDY: ABOUT KNOWING THE ‘GRADE R LEARNER’ OF SCIENCE

In this study we look at one of the three components identified by Bosman (2006:42) for effective teaching of science in the foundation phase; namely *science process skills*. We propose that there is a need for developing *science process skills* from an early age, while children interpret the world according to *intuitive theories* (Carey, 2009) and when they hold naïve concepts. We argue that this is also the time when much conceptual change (Vosniadou & Loannides, 1998) can take place as young children encounter purposeful instruction from a teacher. Furthermore, by developing science process skills early, they can apply these to their advantage in the learning of other subjects, such as mathematics (Ostlund, 1998; Charlesworth & Lind, 2013).

The Grade R classroom could be an ideal ‘laboratory’ to gauge what children’s (naïve) science concepts are and how their cognitive processing of information and experience happens, as witnessed by their actions and their classroom talk. This idea creates a research problem space, because foundation phase teachers are not explicitly trained as science teachers, which makes it difficult for them to introduce activities that may develop science process skills. It is even more challenging to teach difficult science content (including methods and concepts) in such a way that it is relevant to young children. Because the majority of foundation phase teachers in South African schools have not studied science in any depth while they were at school and at university, or teacher college (Bosman, 2006:1) they, too, have limited science content knowledge.

This situation of Grade R teacher *content knowledge* (as defined by Shulman, 1987) of science is one of the motivational factors for this study. It is important to explore early grades teachers’ (scientific) knowledge and view of the natural world *along* with how they understand young children’s science process skills. In Figure 1 the teachers’ knowledge and views are presented as the lens through which she is likely to ‘channel’ her awareness of how children are developing their science (processing) skills.



**Figure 1: The intersect of teacher knowledge and awareness of child learning**

The point we make about a teacher’s knowledge (which includes her epistemological view of ‘science in the world’), is that she will see in children only according to what she knows herself. Her awareness of what young children may be learning will thus be offset against what she herself knows. That is the supposition that we pose at the outset of the study. This means that, at the same time, it is also important to know the extent of teachers’ science content knowledge so that a researcher can qualitatively search for the connection of the teacher’s knowledge and her pedagogy with regard to science process skills of children (Bosman, 2006:5).

For the purpose of this study we work with the notion of early science education as the development of competences (skills) of young learners to see and act upon the (natural and technological) world in which they live with some basic skills.

Following from the discussion thus far, the following research question is posed:

*What is Grade R teachers' awareness of science process skills of children?*

The study aims to *describe Grade R teachers' awareness of children's science process skills.*

### **3. THEORETICAL FRAMEWORK: SCIENCE PROCESS SKILLS**

We refer briefly to what was the genesis of the notion of 'science process skills' in formal school education in the US. The *Science: A Process Approach* (SAPA) was a curriculum design project of the American Association for the Advancement of Science between 1963 and 1974. The designers had argued at the time that the methods applied when investigating the natural (and technological) world require specific skills, which can be learned along with learning science content. SAPA divided science process skills into two groups, namely; *basic* skills and *integrated* skills. Since then, much research in the United States focused on the basic and integrated science process skills (Dökmea & Aydiline, 2009; Baird & Borich, 1987; Padilla 1990, Padillia, Okey & Garrad, 1984; Roth & Roychoudhury, 1993; Goh, Toh & Chia, 1989; Germann & Aram, 1996; Walters & Soyibo, 2001), which develop along a progression or trajectory of learning science concepts.

The six basic skills include; observing, classifying, measuring, communicating, predicting and inferring. These basic skills form the foundation for learning and developing more complex skills - also known as *integrated skills* (Padilla, 1990:1). These integrated skills include, among others, *defining operationally, formulating hypotheses, designing investigations, organizing data* in tables and graphs, *understanding cause and effect* relationships, *formulating investigations analysing* data. Using the building blocks (basic skills) more complex cognitive processes develop (integrated skills) which support the building of scientific knowledge and concept development (Aktamis & Ergin, 2008:3). It is evident from this brief summary of the theoretical framework that there may be some hierarchical development/ learning of skills and that teaching activities could take this into account.

The notion of a learning trajectory refers to a developmental progression in learning (Brewer, 2007:386). Learning trajectories, if teachers can 'see' (and know about) such trajectories, can help teachers understand what learners' know and are *able to do*. As children have different learning trajectories, the learning and restructuring of their already formed concepts can be challenging for them if the learning is not carefully scaffolded by a teacher. We propose that a teacher's knowledge of the notion of the science process skills can serve such a purpose - it can be seen as a set of tools that a learner constructs through response to certain teaching activities that help a child to observe and process scientific information, solve problems and develop and restructure concepts (Aktamis & Ergin, 2008:1). For teachers to plan their classroom activities with a science process skills approach to pedagogy they first need to have some *awareness of such discrete skills* (which are both perceptual and cognitive), and also some science content knowledge. Secondly, teachers are required to have a clear understanding of the difference between *basic-* and *integrated* process skills, what each skill entails, how these skills apply to the learning content and conceptual development of the learner and how these skills can be identified in the teaching and participation activities.

#### **3.1 Emerging science in early childhood education**

Human infants have an innate capability to observe their surroundings and to act upon it (diSessa, 1993) in whichever cultural milieu young humans may find themselves. With the help of verbal communication they are also able to learn rapidly from elders (Carey, 2009). School education is, generally, a major source of learning; the key goal-setting of science education in different curricula is to promote scientific literacy, thus 'formalising' intuitive and naïve knowledge (Harlen 2000:11). A part of this is also to enable children to use science process skills (Aktamis & Ergin, 2008:1).

The fostering of scientific literacy (with science process skills) in the foundation phase involves careful consideration; it recognises the diversity of children in terms of life experiences, interest, and

capabilities as well as language of learning (Joyce, Weil & Showers, 1992:20). The emerging of science concept development and refinement in early childhood education is supported by the findings of Eshach and Fried's (2005:332) research. They argue that children enjoy thinking, observing and exploring nature and that they develop positive attitudes towards science knowledge when they are exposed to such knowledge early in their lives. Furthermore, they propose that children gain a better understanding of future scientific knowledge and concepts when they are exposed to learning opportunities early on. Harlen (2000:23-24) agrees with Eshach and Fried (2005) and argues that children are able to start learning at age three and are able to develop 'nuanced' early pre-concepts. Harlen (2000:23-24) also discusses the valuable outcome of developing a positive attitude and love for science, as the values and attitudes of science moves from being self-orientated to orientated to others and the motivation moves from an internal to an external social drive – learning with and from others (Harlen, 2000:27).

Eshach and Fried (2005:332) found that although teaching science in the early grades is difficult, it has distinct advantages. Yet, natural science and developing of science process skills still seem to need pedagogical justification in the foundation phase of the South African curriculum. We would argue that the rationale and method for inserting emerging science in early childhood education still needs to be developed systematically. For that reason it is important to discuss the developmental place science process skills have in the young learner's trajectory and how it could be incorporated in the South African curriculum.

### **3.2. Science process skills and the young learner in the South African curriculum**

Rambuda and Frazer (2004:10) explain that the continuous transformation of South Africa's educational system and especially the curriculum renewals have negatively affected teaching practices as it caused more gaps in the education field, which, in turn, has caused a decrease in the quality of teaching. Although things seem to be stabilising 12 years after this comment, there remains a concern that too many changes militate against stability and advancement. In the Curriculum and Assessment Policy Statement (CAPS) for Life Skills in the foundation phase (Department of Basic Education, 2011) the *beginning knowledge* section includes natural science, social science and technology, which, in total, is only allocated one hour per week of teaching. Although two types of science process skills are addressed in the curriculum, namely the inquiry process and the technology process skills, the curriculum for this 'subject' does not clearly advocate for an integrated approach of how these skills also relate to other subjects and to the range of basic process skills. Yet, in the early grades, *integrated subject teaching* is important. The view of this study is that through the design of inter-subject classroom activities, some of the skills needed to become adept at scientific inquiry can be spread across the curriculum, specifically the language and literacy curriculum as well as the mathematics curriculum.

Moreover negligible guidance to teach and develop these skills - and giving it 'beginning knowledge' status only - does not help teachers much. They, generally, are *not* preparing learners for the intermediate phase curriculum, which consists of the following very demanding knowledge strands; life and living, matters and material, energy and change and the planet, earth and beyond (Department of Basic Education, 2011:8). These strands are developed from the biology, chemistry, physics and astronomy fields. The strands are very broad and not clearly identified in the foundation phase curriculum. Moreover, science process skills related to these different strands are not explicated in the curriculum and seldom feature in the foundation phase classroom.

Roth and Roychoudhury (1993:128) identified two challenges for successful implementation of teaching science process skills in the classroom. Firstly, skills are not practiced discretely. Finding yourself in a real-life situation often leads to the use of numerous related skills simultaneously, making it difficult to distinguish and separate skills to teach and implement them effectively. Secondly, defining the skill causes difficulty, as broadness and interdependent characteristics of more than one skill occur.

Teachers often include activities that require the use of science process skills without explicitly including it in the planning of these activities. This study wishes to address this *lack of awareness*.

Such an awareness could lead to teachers not only focusing on mediating knowledge through the content but also focus on teaching the process of science inquiry and how learning can take place through discovering not only content knowledge, but ‘discovering’ the processes which lead to knowledge (Fleer & Hardy, 2007:122). Careful planning has to go into the teaching of that broad subject called ‘life skills’ so that science processing is infused in an integrated manner beyond that curriculum, migrating to maths, language and literacy, including the whole ‘beginning knowledge’ curriculum. Several researchers link effective learning of science and other subjects, including mathematics and literacy, with the development and use of science process skills in teaching activities (Brotherton & Preece, 1995; Harlen, 1999; Keys & Bryan, 2001; Walters & Soyibo, 2001). Science process skills, approached in this way, facilitates learning over a spectrum, not necessarily aiming to develop all children as future scientists.

Meador (2003) argues that not all children will become scientists or choose a career in a science related field, but through developing these skills from an early age, reasoning and problem-solving techniques are formed which are applicable to daily activities and several occupations. Ostlund (1998:2) elaborates on the positive effects of science process skills on learning, especially the performance in reading, language, arts and mathematics. Ostlund (1998:2-3) found that when teachers develop science process skills, logical thinking and the basic skills of reading processes are simultaneously being developed. Furthermore, science experiences enhance operational abilities (mathematics) of kindergarten children that facilitate the levels of transition in cognitive development when they are older. By replacing current approaches of teaching abstract mathematic problems with real-world science problems it has the potential to enhance children’s problem-solving abilities. These skills help children to understand and *critically reason about concepts*, rather than just accept factual knowledge. They apply conceptual knowledge in a process.

In conclusion, although the foundation phase curriculum does not require the teaching of science in depth, there exists an urgent need to investigate all activities in grade R classes in order to gauge the extent to which the development of science process skills is neglected and how they could be advanced. It is crucial to investigate whether the activities that grade R teachers use show that they have an awareness of science process skills and also what their own science knowledge constitutes as several authors (Carey, 1985; Bosman, 2006; Harlen, 1999; Eshach & Fried, 2005; Ostlund, 1998) argue the importance of science process skills in early stages of science concept development and the direct influence in other teaching activities and subject learning.

#### **4. METHODOLOGY**

In this descriptive case study data were collected by way of semi-structured interviews with six teachers. The ‘bounded system’ (Stake, 2005; Yin, 2013) of the case was teachers’ views of the phenomenon of science process skills in the Grade R classroom. The inquiry was a descriptive case study that set out to capture the teachers’ work in the public and the private school systems, including pre-schools that offer grade R education. The schools and the teachers were selected purposefully (Henning, Van Rensburg & Smit, 2004) to explore the *bounded system*. The nature of the interviews was conversational aiming to elicit teacher’s awareness of science and science process skills in the foundation phase, specifically in grade R. The interviews were conducted from February to April by me as the researcher. The interviews were audio recorded and then transcribed. Informal classroom observation also took place after the interviews. The data were analysed for content (Bottorff, 1994:253; Henning et al, 2004). The coding process consisted of three stages as suggested by Strauss & Corbin, (1999; O’Donoghue 2007:91-98) namely; open, axial and selective coding, in typical grounded theory mode. The reliability of the data was increased by allowing the data to be code by two independent individuals, where after they reconsolidate the categories to construct themes.

## 5. RESULTS

The interview responses were coded in order to find themes that emerged from the teachers'. The table that follows provides an outline of these themes and sub-themes or categories. A discussion of these findings follows in section 6.

**Table 11. Summary of emergent themes and sub-themes**

Theme	1) No form of formal science present during a typical school day.	2) Preparation for further schooling does not include the development of science process skills.	3) Classroom management and learning challenges that inhibit effective teaching of concepts.
Sub-theme	1) Teachers' notion of science in the foundation phase 2) Factors influencing teaching and learning methods 3) Examples of activities included during daily teaching 4) Teaching aids used in the grade R classroom to guide teaching and enhance learning	1) The importance of grade R as foundation for further schooling 2) An overview of the characteristics of grade R 3) Development of skills in the various domains of holistic development	1) Systemic issues 2) Operational issues

From the data analysis it was evident that all six teachers do not have an acute awareness of the importance of science in their teaching. Two of the three themes that emerged from the data show that these teachers are more aware of other factors that they deem to be important in their teaching. None of the teachers mentioned any notion pertaining to science during the more generic interview questions. It was only after they were prompted about the importance of science that the teacher's responses included factors pertaining to their awareness of science. The third theme that precipitated from the data focused on the systemic and operational issues raised by the teachers that inhibit them from teaching new concepts effectively. What we find notable was the fact that some of these factors were not found needed to teach science effectively. It was clear that the teachers relied on external resources such as finance and technology to improve their lessons, rather than relying on evaluating teaching methods, styles and activities that will teach children skills and help them construct and deconstruct concepts so that future learning will be effected positively and so contribute to the sustainability of future education.

## 6. DISCUSSION OF FINDINGS

### 6.1 Theme 1: No form of formal science present during a typical school day.

#### Teachers' notion of science in the foundation phase

What was evident from the interviews is that none of the teachers mentioned science or science process skills explicitly unless they were prompted to answer questions that specifically referred to science. Only after being prompted all six teachers felt science is important and should be introduced in early childhood. One of the teacher however mentioned that science is everywhere and part of everyday life as children are exposed to scientific concepts daily and should be introduced informally in grade R. During informal classroom observations we found that most grade R children only get exposed to science when the teacher sets up a table with some objects or items, as if their mere presence will inflect the development of science process skills. There are indications that the teachers are aware of what science process skills was, although they had different names for these skills and does not explicitly refer to them as the 'science process skills'. The necessity to expose children to science from early childhood is argued by many researchers (diSessa, 1993; Carey, 2009; Aktamis & Ergin, 2008; Joyce, Weil & Showers, 1992; Harlen, 2000; Eshach & Fried, 2005), yet five of the six teachers

mentioned they find it difficult to teach concepts in a way that is relevant to the young child, therefore they only teach concepts superficially without the necessary vigour required.

### **Factors influencing teaching and learning methods**

All the teachers perceived visual learning as most important, however two teachers argued that auditory learning is neglected and that over stimulus of visual inhibits listening skills that affects learning new concepts. The teachers state that learning takes place through discovery and desk work, however, in comparison with a study in the United States on the views of kindergarten teachers from different generations that shows that kindergarten is perceived to be the new first grade (Bassok, Latham, Rorem, 2016:1), dramatic differences in teachers' expectations and classroom structure were found. In the US much more desktop work is being done to ensure that learners are prepared for grade one, causing a radical shift from the development of necessary skills for their age by limiting non-academic subjects such as art, motor development, and music. A few statistics from this research has shown that 80% of current teachers believe children need to know the alphabet and learn to read before grade one, 76% of the teachers don't believe that water or sand tables are valuable learning and development resources and 40% of current teacher's report that children only spend 1 hour on child-selected activities. Although not much research has been done in South Africa on the educational shift of "replacing" grade R with grade 1, a strong correlation is seen after analyzing the interviews. All these factors influence the effectiveness of teaching content and development of skills. Teachers need to move away from the traditional methods of teaching by designing more physical and intellectual activities, such as tactile and hands-on experiences. Participation, interaction and movement was seen as some of the factors important to learning as children learn by sharing their own experience. Teachers' emphasised that the teaching methods need to cater for the child's nature. This however, needs to be confirmed in lesson observations that will form the second phase of data collection for a larger project that this study forms a part of.

### **Example of activities included during daily teaching**

No indication of the importance and place of science in the daily activities and curriculum outline and lesson framework was mentioned during the interviews. Teachers emphasised that the curriculum is seen as the driving force of their teaching and therefore they only focus on math and language and literacy. All teachers mentioned the importance of including creative arts in their daily activities. The teachers said that it is important to link lessons, yet during the preliminary classroom observations no attempt to integrate knowledge from other subject fields were seen in the teachers' teaching. All six teachers mentioned that play and physical activities need to be incorporated with learning and that questioning and discussions is important to learning but none could explain from a development or theoretically sound point of view why including these activities are beneficial. It appears that the teachers act out of strong intuitive commitments without eluding to a deeper comprehension of learning mechanisms.

### **Teaching aids used in the grade R classroom to guide teaching and enhance learning**

From the responses of the teachers we could determine elements that they considered important in aiding the learning process. These elements included the use of art, knowledge of own body, discussions and senses. It remains to be seen if the responses of these teachers relay to their classroom practice.

## **6.2 Theme 2: Preparation for further schooling does not include the development of science process skills.**

The responses of the teachers exhibited limited awareness of the importance of the development of science process skills. It could be deduced that these teachers do not explicitly value the inclusion of science process skills in their teaching. All agreed that grade R is essential in preparing children for further schooling but few could describe what exactly this preparation would entail. They would explain the importance of grade R in a broad sense describing grade R as "the foundation for primary

school” but from their responses it was clear that the development of mathematics, language and art took preference above the learning of science.

### **The importance of grade R as foundation for further schooling**

Grade R is seen as the most important year of the most important school phase as it sets the foundation for schooling. It prepares the child for what to come and introduce the notion of formal work and assessment. All the teachers emphasised that grade R creates enough opportunities to experience new things. At this stage it isn’t clear whether the inclusion of science content or skills are included in this statement. We argue that science content and skills present ideal opportunities for children to “experience new things” with the added benefit of including subject matter from various other school subjects. This presents a case for the integration of content from all subjects in teaching.

### **An overview of the characteristics of grade R**

Grade R is perceived as being informal, has less pressure, slower pace and forms a foundation where children can learn to follow instructions. One of the teachers emphasised that grade R is spontaneous and creative where a lot of play takes place. All six teachers mentioned that grade R builds self-esteem and in the two preschools the grade R learners are seen as the leaders of the school. The informal nature of grade R presents benefits in the sense that science concepts and skills can be included in all activities.

### **Development of skills in the various domains of holistic development**

All six teachers agreed that grade R is exceptionally significant to the holistic develop of children. Grade R is the foundation for schooling that allows teachers to address developmental gaps. All the Grade R teachers are acutely aware of the role that free play plays in developing motor skills and social skills but failed to elude to the benefits it could have for the development of science process skills. The development that takes place in grade R in all the different domains of a child will influence future development and learning (De Wit, 2009). All the teachers showed good understanding that Grade R is informal and that play develops social skills, however according to Louw and Louw (2007) play develops more than just social skills. These teachers’ perception showed that Grade R’s prime focus is that of motor development. We agree that the holistic development of children is important and present a case for the inclusion of science process skills as it could be beneficial to the holistic development of children.

## **6.3 Theme 3: Classroom management and learning challenges that inhibit effective teaching of concepts**

Although not a unique phenomenon with only the grade R teacher we feel that this theme is of great concern to the teaching of science in grade R and in the Foundation Phase as a whole. Systemic and operational factors often inhibits teaching especially if the teachers aren’t resourceful in creating teaching aids. Teachers often have a misconception that the teaching of science should include the use of typical laboratory equipment like glass beakers, test tubes, etc. Resourceful science teachers can identify everyday items that are neither costly nor difficult to acquire to include in their lessons.

### **Systemic issues**

Systemic issues regarding grade R included; lack of managerial support as the rest of school does not understand the challenges of grade R, one teacher mentioned that grade R is seen by the rest of the school as a place of arts and crafts. Lack of parental involvement and non-attendance. Teachers feel that there is a great need for assistance or smaller groups as big class sizes is a barrier to learn new concepts and more working and playing space is needed.

### **Operational issues**

Operational issues regarding grade R included; grade R learners have a short attention span causing a concern for learning and that repetition is therefore needed, however repetition may cause learners to

be bored. Maintaining discipline is challenging as learners do not always follow instructions and test the teachers' boundaries. The learning of new concepts is inhibited due to discipline challenges. The inclusion of science process skills development could resolve this challenge as it allows the children to be more engaged and act autonomously. More relevant resources are needed by the teachers to allow them to teach new concepts. For the teachers these resources include social media and internet as children are more exposed to a 'virtual life', however a lack of financial support of two of the four schools obstructs these resources.

## 7. RECOMMENDATIONS

From the findings the following recommendations are made:

- Further investigation is needed to identify how grade R teachers make use of developing the science process skills in different pedagogical activities.
- As most novice teachers did not have any exposure to science during their own schooling, teacher training institutions should develop and implement modules that will further enhance novice teachers' science content knowledge.
- The type of activities in Life Skills (beginning knowledge) for foundation phase should be revised to make the notion of science process skills more clearly.
- In-service training and professional development workshops should be offered by the education department in conjunction with higher education intuitions and local businesses to teachers to assist them in teaching science in a way that is relevant to young children.

## 8. CONCLUSION

This study aimed to exemplify teachers' awareness on the development of science process skills in children In Grade R. It was noted that ample research on the development of these skills has been conducted in other countries, but an in-depth study on these skills and how the type of activities that is in-line with the current curriculum within South African schools was lacking. The findings show that Grade R is seen as the most important year of a child's school career as it develops the foundation for future learning, yet from the interview it was clear that very little prominent focus were placed on science within a typical school day and that the preparation for future schooling does not include the development of science process skills. Furthermore, classroom management and learning challenges inhibit effective teaching of concepts. Teachers find it challenging to teach science process skills and science concepts in such a way that is relevant to young children. But, children don't need to be "little Einsteins" to develop science skills and knowledge, as they use naïve concepts and intuitive theories which are based on their emergent ideas and prior knowledge (Naude, 2015). Children's explorations, experiences and views of the world and their social context enable them to form naïve concepts that can develop into intuitive theories (Carey, 2009). This paper argues that it could benefit children if their teachers had more knowledge of children's early (naïve) concepts and their first theories of the world.

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