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Self-Regulation in Early Years of Learning Mathematics: Grade R Observed Self-Efficacy Skills Shared and Aligned

Nosisi Nellie Feza

Abstract

Numeracy development of young learners has been proven to be innate. Research asserts how 6 months old infants were able to subitise group of quantities. The inner ability integrate itself with their curiosity as they develop further. Kammii also asserts that young children develop autonomy through their observations and curiosity of figuring out events. This indicates that, children have natural independent abilities for learning. However, schooling seems not to be able to maintain this. This chapter demonstrates through clinical interviews how this independent discovery occurs and such observations can be used to observe trends that inform Grade R/reception class numeracy instruction. Intellectual autonomy as presented by Piaget and Kammii is used to analyse students' data to elicit trends and themes that influence instruction to maintain self-regulation in their development. This chapter employs qualitative enquiry in getting insight to student's intuitions and how they contribute to independent learning.

Keywords: independent learning, numeracy, autonomy, self-efficacy, intuitions

1. Introduction

Independent learning is a powerful skill needed by all students across nations to achieve and reach educational levels that will address societal challenges and eradicate poverty. The fourth industrial revolution demands creative thinkers to make connection between technology and soft skills. This cannot be realised if students are highly dependent on educators for their own learning. However, many students do not possess these skills. The sad thing is that these skills are natural skills a child is born with as they try to venture their world. New born babies are explorers of their world in order to navigate it safely, know it and conquer it.

Literature suggests that active participation of children in their mathematics development lead to improved performance especially for children from low socio economic backgrounds [1, 2]. This active participation is promoted through games and resulted in increased number development of young children [1, 3, 4]. This chapter capitalises on these innate abilities and intuitions of children as bases for their independent learning and mathematics development. Young children have natural curiosity and elasticity to learn new ideas and explore new things.

This could be used for their benefit in developing their self-regulated skills towards learning. This chapter teases out these intuitions to inform instruction of young students that nurtures independent learning and self-regulation skills. This chapter aims to explore young children's mathematical intuitions before they enter formal schooling. This is achieved by conducting clinical interviews with 5–6 years old entering reception class for the first time. These intuitions are explored to inform research on possibilities of developing self-regulation of students while they are young and flexible to attain good habits, furthermore natural self-regulation can still be nurtured and sustained during the early years of education. This chapter responds to the following questions: (1) How do young children demonstrate their mathematical intuitions? (2) How are these intuitions aligned with curriculum specifically South African Curriculum for reception class? and (3) How do these intuitions mediate self-regulated learning?

2. Young children's mathematical intuition

Jung [5] and Kammii and DeClark [6] describe young children's mathematical intuitions as internal abilities possessed by young children. In discussing the origins of such abilities [5] employs Piaget's three kinds of knowledge: "physical; logico-mathematical and social" (p. 7) knowledge. The difference amongst these knowledge is derived from their sources and modes of structuring. Physical knowledge is knowledge of "objects in external reality." This knowledge can be observed, touched or felt using senses. This knowledge cannot develop without external influence or experience. On the other hand, logico-mathematical knowledge is formed internally through connections that are mentally made. For example, [5]'s story of a 6-year-old girl trying to understand the concept of Santa Claus. This girl started noticing some patterns about Santa Claus that made her ask some questions such as: "How come Santa Claus uses the same wrapping paper as we do?"; "How come Santa Claus has the same writing as Daddy?" (p. 45). Kammii's story of Santa Claus indicates that a young child believes all what her parents tells her. However, as she develops she begins to make connections in her brain. The girl in Kammii's story believe in Santa Claus/Father Christmas in South African language but one day he made some observations: (1) she observed that Santa Claus's writing on his presents is the same as her father, and (2) the way the presents are wrapped is the same as the way her mother wrap up presents at home. This pushed the girl to make connections that, she never met Santa but Santa always knows what she wants. She therefore realized that there is no Santa as Santa is her father assisted by her mother in wrapping up the present. This indicates that the external or physical knowledge observed was then internalized by this child and became internal knowledge and connections were made and a logico-mathematical knowledge is formed.

Furthermore, [6–8] affirm that children demonstrate spontaneous quantitative recognition at a young age. This spontaneity is a natural ability that is identified as intuitions by researchers [9]. For example, at 6 months old children are able to discriminate small numbers [6]. Clements [7] suggest that this skill demonstrated by the children at this infant stage is subitizing. Hyde and Spelke [10] extend this discovery by suggesting that babies under 9 months own two systems of nonverbal numerical cognition: one that is retorting to small quantities of individual objects and the other to approximately larger quantities. These systems contribute to the development of counting skills [11]. In addition, [12] brings forth the spatial intuitions of children's crawling which allows them to navigate and understand space. The above literature clearly indicates children's mathematical intuitions that need one to tap on in developing them further and deeper. For this chapter the big

question is on how does this intuition assist in developing independent learning of mathematics to young children? Kammii presents Piaget's concept of autonomy as a vehicle to mediate mathematics to young children capturing their intuitions and interests to nurture independent development.

3. Autonomy

The autonomy concept comes from Piaget's theory of construction of knowledge that originates from children's experiences of their world. The intuitions discussed above resonates well with the children's experiences. These experiences happen through senses physically. Kammii and DeClark [5] defines autonomy as being directed by yourself. In other words, being self-driven. In the case of mathematics learning the concept of autonomy will refer self-dependency and independent learning. There are two types of autonomy from the original theory: moral autonomy and intellectual autonomy.

3.1 Moral autonomy

Moral autonomy is an ability to choose between right and wrong without pleasing others taking own responsibility for doing the right thing without expecting any rewards [13]. This ability is one of the important characteristic needed for leadership and citizenry. Kammii and DeClark [5] advocate for nurturing of this ability to children at an early age to develop responsible, accountable, adults with integrity.

3.2 Intellectual autonomy

Intellectual autonomy is important for successful learning because it challenges the mind. Feza [13] describes intellectual autonomy as "the connection made by children within the physical world that leads them to question things they observe that do not connect" (p. 63). The curiosity demonstrated by children in knowing more and relationships made between patterns. For example, a young child when s/he gets a toy plays with it for a moment and start dismantling it until it is broken, once it is in pieces the child will try hard to rebuild the toy. This indicates that when the child was breaking the toy into pieces the purpose was not to destroy it but to figure out something about its composition. Therefore, after seeing all the components of it the child wants to be able to deconstruct it, but unfortunately cannot and they cry with frustration.

Another example of figuring out things come from [14] as a unique difference between animals and humans. A story of a crawling baby and a dog fetching a cloth stuck on the tree explain Vygotsky's meaning of this difference. In this story the baby and the dog are playing with a cloth amongst the two. A strong wind came and snatched the cloth and threw it on the branch of the tree. The dog started barking and jumping in attempt to reach the cloth the baby on the other hand sat and looked up. After sometime the baby crawled towards a stick lying on the ground. The baby took the stick and crawled back to the tree with it he tried to reach the cloth until on the third attempt the stick hooked the cloth and the cloth fell on the ground. This story again supports Kammii's example of Santa Claus. The baby observed the physical space and distance and realised that, nor matter how high the dog jumps, it's strides are small and the distance is longer. Therefore, the baby looked around for something that can cover the observable distance and found a stick.

The stories give account to children's intellectual autonomy that needs to be nurtured by educators as it arises. A number of opportunities come in classrooms

but are ignored. This chapter advocates for nurturing of intellectual autonomy that is innate to young children to nurture self-efficacy, and independent learning.

4. Nurturing self-efficacy of young children

Self-efficacy means independence and self-driven individual. Feza [15] synthesized a number of strategies to nurture mathematics stimulation of young children form the literature on early childhood mathematics. These strategies align in allowing children to use their intuitions to guide learning and instruction, hence they nurture self-driven learning. The strategies are as follows:

4.1 Purposeful play for mathematics development

Play on its own draws on young children's interests, curiosity and intuitions leading to full voluntary participation. The power of play resonates with peer interaction, development of vocabulary through interaction, development of social skills through behaviour and development of team work attributes [16, 17]. Hence, in mathematics block building nurtures spatial relationships and problem solving. It is during this play an educator can tap through observation into children's interests with the aim of extending them for further development.

4.2 Scaffolding children's mathematics learning

Scaffolding is a concept that originates from Vygotsky's theory of social construction where scaffolding refers to the extension of the student's level of thinking [14]. Having observed the children playing or doing their own directed task the educator has to first identify the child's level of thinking through observations and engagement. Once the child's level is identified the educator can participate as a peer to assist the development of the next level of thinking. For example, a group of children were playing with pattern blocks sorting them. Their sorting rule was not clear whether it is by shape or colour since the same shapes share the same colour. The educator took a green block and asked the group to tell her where to place it. The group pointed her to the green triangles. That gave a hint to the educator of where the learners were. This also give the educator an opportunity to bring another block of a different colour and ask learners where to place it a colour that does not match others to start an intentional conversation [18].

4.3 Developing mathematics from children's activity

Cognitively guided instruction (CGI) designed by [9, 19, 20] encourage educators to allow students use their intuitive strategies. This approach has proven to have significant gains on young students' mathematics performance. These studies proved that students' intuitions when allowed to be employed in problem solving, self-esteem and mathematics confidence of students increases [9]. This lead to self-regulated behaviour in learning.

4.4 Encourage and provide manipulatives for exploration and inquiry

As indicated by [5] young children make more sense of the physical knowledge and therefore need physical manipulatives, and virtual manipulatives to explore and learn through the exploration. Jung [21] suggest that educators provide a variety of manipulatives and representations to extend and challenge

children's thinking. Sigler and Ramani [3] also suggest use of non-examples to develop higher levels of thinking.

5. Research design

This chapter employs qualitative inquiry as it aims to provide insights on young leaners intuitions of mathematics in their free play. In order to achieve this aim interviews together with observations are used as exploring tools that will unravel these intuitions giving insights into learners mathematical thinking that exist before their formal schooling.

5.1 Participants

The chapter reports data from a three-year study that was funded by the National Research Foundation (NRF). The data reported was collected from 67 reception class students in five primary schools in the Eastern Cape. These schools are part of the funded project that provides professional development to educators of the 5–6 years old.

5.2 Ethics approval

Parental consent and learner ascent was negotiated and granted for all learners and educators participating in the project. However, for this study not all learners with consent from parents participated. In each school 15 students were selected across reception classes participating in the study. The selection was conducted by the students' educators prior beginning of the formal instruction in the beginning of the year. This chapter reports only on 67 students' data due to poor recording of the interviews and few learners who lost interest and left during interviews. In addition, an ethics approval for this study was also received from the authors' university. It is important to note that learners' comfort was important during data collection. Learners were allowed to leave the room when they needed to and also when they lose interest they were allowed to take a break and come back if they want to. Only few learners left before completing the interview in general less than 9.

5.3 Instruments

An interview protocol was developed on students' intuitions of mathematics. This protocol was accompanied by manipulatives to be used freely by students. The 20 minutes, interview protocol was piloted to six 5-year-old students in a primary school in Gauteng Province and revised after the analysis of the pilot data. The following **Figure 1** is a picture of manipulatives students were playing with during interviews.

It is important to note that the interview protocol allowed for questions guided by learners' play and activities. Students were left to play with the bottle tops for 3 minutes without interruption, then the interviewer asked to join in the game asking students to show her the correct way of playing. While playing, the interviewer probed about the interest of the student on the activity and if s/he will be willing to share it with others. After a while the interviewer does the pattern on **Figure 2** below and asks the student to play with her following her rules.

The interviewer gives the student a chance to develop his/her own pattern if possible. The same procedure continues with the shapes and pattern frames, except that for the shapes in **Figure 3** learners are asked to fill up the pattern frames.

Figure 1.
Counting manipulatives.

Figure 2.
Pattern demonstration.

Figure 3.
Shapes and pattern frames.

5.4 Data collection and analysis

This data was collected towards the end of January; this indicates that these students were not yet involved with their formal schooling some were from pre-schools and some from home, as January is the beginning of a new year in South Africa. Video cameras were used to observe students' actions and field notes were also taken to triangulate the two data sources. The collected data was then captured on an excel spreadsheet following the interview procedure and making notes of all the data captured. The field notes were neatly typed and annotated separately using [22] iterative process. The codes that came from the field notes and the spreadsheet were then triangulated. In engaging with these codes analytical memos were written. The analytical memos together with the codes were triangulated and revisited using raw data as evidence and themes started emerging. The biographic data was analysed using frequencies. A thematic report is used to present the findings.

6. Results

Some background data indicate that only 11 out of the 67 students reported that they did not attend pre-school or day-care before reception class. All these students come from the low socio economic background attending no fee schools.

The thematic report responds to the following questions of the study: (1) How do young children demonstrate their mathematical intuitions? (2) How are these intuitions aligned with curriculum specifically South African Curriculum for reception class? (3) How do these intuitions mediate self-regulated learning?

The two themes that emerged from the analysis give integrative response to the three questions of this chapter.

6.1 Free play stimulating mathematical concepts

6.1.1 Counting

Most students first reaction on manipulatives was to count them, whether they know how to count or not. All 67 learners were able to do **rote counting sequentially** to 50. This is observed as they count sometimes re-counting bottle tops they were able to proceed to 50 without accurately counting the objects. About 42 out of 67 were able **to count objects** accurately until 27. However, some of them could not respond to "how many" about 23 of the 42 learners, instead they used their fingers that became their immediate tools to respond to the question of "how many" when asked by the researcher, each finger representing a bottle top. Only 19 of these learners were able to respond to the **"how many"** question. An interesting observation from the group that could respond to "how many" is that their bottle tops are organised in **a particular structure** which makes it easy for them to do object counting and keeping track of their counting as shown in **Figure 4**.

On the other hand, those who only do object counting lack the structure although they are able to count the objects accurately in **Figure 5**.

Meaning their **eye co-ordination** is good and assists them in keeping track of the counted and uncounted bottle tops. All this counting **is learner directed** except the "how many" question that comes from the researcher. When the researcher demonstrated the pattern to the learners, learners could not follow. They all struggled and moved on with their own activities after trying.
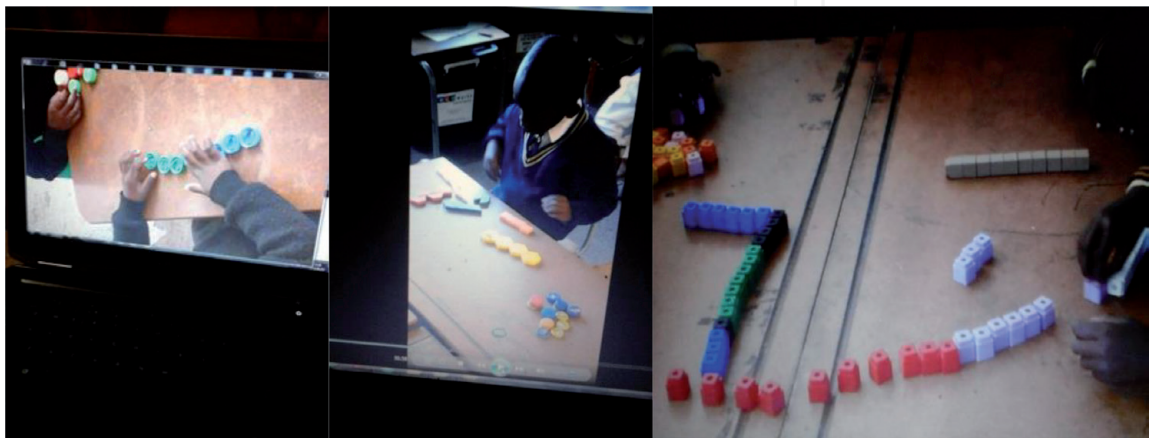
Figure 4.
Students structured counting strategies.

Figure 5.
Students unstructured counting strategies.

6.2 Three dimensional emerging spatial intuitions

6.2.1 Building of shapes

Those who did not start by counting they made **geometrical structures** some of which were rectangular houses, yards in square shape and sleeping beds also in rectangle shapes. Most of their structures represented items at home or their homes and were more skewed toward three dimensional reasoning.

6.2.2 Sorting

Bringing similar colours together by grouping them happened naturally from these students. Even when students encountered shapes, their first reaction was **to sort** them **into colours** before any other activity they wish to do. With shapes the sorting was including similar shapes together in the sorting.
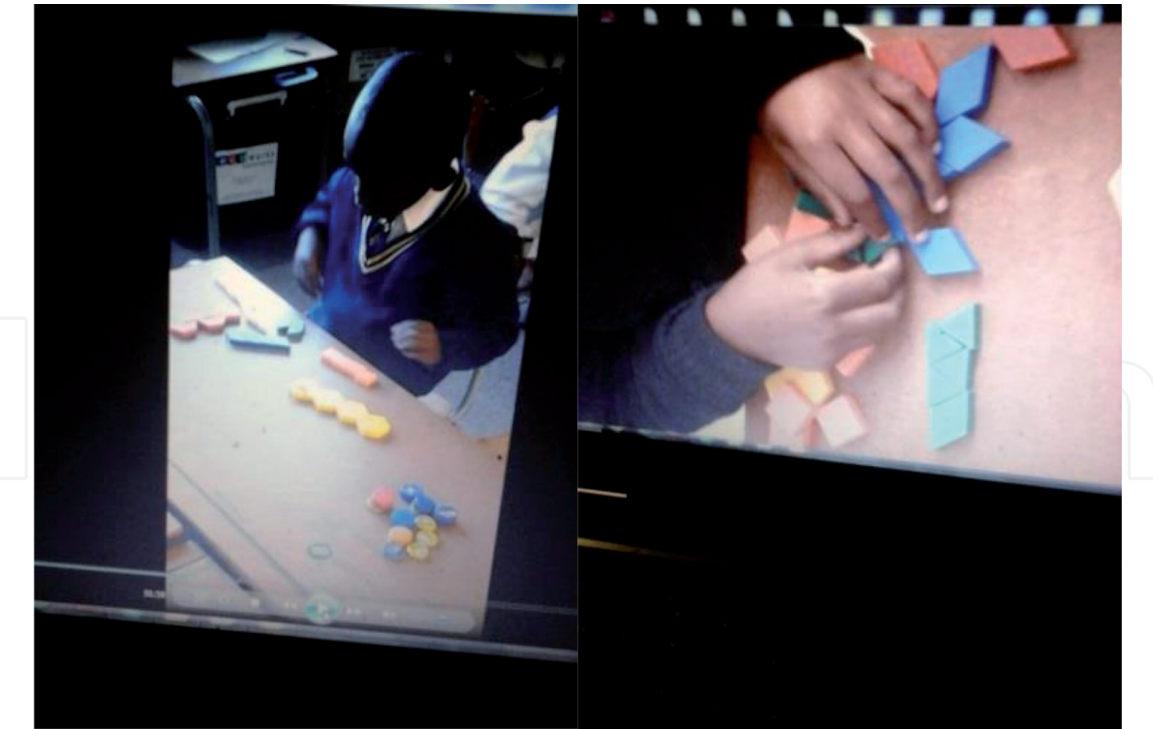
6.2.3 Tessellation

Tessellation of shapes became some of the students' activity and the amount of time spend on it was greater than other activities. This tessellation was **side by side** tessellation as shown in **Figure 6**.

The tessellation of shapes that emerged from learners created an assumption that they will be enjoy and be able to complete the frames using the shapes they were playing with.

6.2.4 Piling

When learners are given these pattern frames to play with below are their strategies. Some learners tried to fill up as shown in **Figure 7** but were challenged by the angles. Some learners piled up the shapes instead of filling up the frames.

Figure 6.
Students' tessellation structures.

Figure 7.
Students' piling of shapes.

7. Discussion

Generally, the findings show the importance of free play in providing educators an opportunity to get access to students' intuitions and interests. Secondly, it is important to observe children without interfering and be patient in order to gain entree to their way of thinking. For example, when the researcher observed that students were tessellating shapes, she made an assumption that they will enjoy filling the pattern frames, instead students piled the pattern blocks to indicate how the perceive space. This could allow the educator to understand that the two dimensional space is not the first practical encounter for young students. Building structures might have become natural for these students. This also challenges the curriculum that always introduces the two dimensional space to students first versus connecting with their experience of the three dimensional space.

Aligning students' intuitive activities with the curriculum guide educators in understanding that counting and its concepts are innate abilities that need to be nurtured from the student's point of view. The findings of this study highlight the counting concepts such as rote counting, object counting, cardinality as concepts

that are already there and need nurturing with stimulating interesting activities and games. The only difference is the level of some learners versus curriculum expectations that are lower. DBE [23] in the curriculum assessment policy statement requires reception class learners to count from 1 to 10 meaningfully. On the other hand, the majority of these learners exceed 20 in counting objects. The question is, what does it mean to these learners when the teacher has to teach them to count from 1 to 10 the whole year while they came to this grade counting more than 20? How do these learners conceptualise the role of school? These findings speak to the research in early childhood mathematics stimulation. According to [3] the majority of these learners are on the progression level of one to one correspondence. Some about 20 are beyond this level at the cardinality level and counting on level. The role of the educator here is to extend these learners' developmental levels to ordering of numbers, composing and decomposing numbers, and the emphasis of the value of the number using objects and number line. However, the curriculum does not indicate so. Is South African mathematics curriculum of the reception class aimed at the level it is supposed to? Literature has indicated that educators who do not have high realistic expectations to their learners impede successful learning [24]. These findings challenge the role of curriculum itself in developing learning at this level.

These findings support the literature on young children's intuitions and intellectual autonomy. Students in this study are interested in counting and have abilities that can be advanced through scaffolding and teacher directed activities at some point mathematising their activities as literature indicates [3, 14]. Already, these students are self-driven their free play shows how they want to try new ideas and learn. In the shape activities it is clear that their experiences are limited, this points to the educator's role in exposing them to puzzles and more activities of similar nature. This chapter argues for nurturing of students' intuitions extending them into formal mathematics without discouraging student's curiosity and interests. In a nut shell this chapter calls for educators to allow student to reach "self-realisation" in their learning through the student's interests.

8. Conclusions

The findings of this chapter reveal that young students have mathematical intuitions regardless of their socio-economic status. These intuitions form a rich foundation for nurturing independent learning. Students also indicate interests in exploring geometrical ideas like building structures. In this study curriculum for these students is aimed at a lower level. This has influence on how students can lose interest in their learning as it undermines their abilities. This loss of interest is the main variable that takes away curiosity and eagerness to figure out new things and new experiences. The role of schooling becomes a disabling one than a developmental. Therefore, this chapter recommends curriculum that sets high expectations and teachers who respect and embrace students' interests for their development.

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Conflict of interest

The author declares no conflict of interest.

Author details

Nosisi Nellie Feza
Central University of Technology, Bloemfontein, South Africa

*Address all correspondence to: nosisi.piyose@gmail.com

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