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Elements of the physical learning environment that impact on the teaching and learning in South African Grade 1 classrooms

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Foundation phase teachers in South African schools follow a socio-constructivist approach to the teaching and learning of mathematics, which entails that learners experiment freely with concepts and are encouraged to communicate and share their thoughts and ideas. In an effort to understand the impact that the physical learning environment, such as noise or large class sizes, have on learning in South African foundation phase classrooms, this study deployed a qualitative case study design to gain insight into the learning and teaching that take place in Grade 1 classrooms. From a cognitive load perspective, the study found that noise, as result of the large number of learners in the class, as well as noise from the outdoor environment, contributes to the overload of learners' working memory, which ultimately impacts negatively on learning. The study also found that the large classroom sizes in Grade 1 prevented teachers from rendering effective support, which causes uncertainty among learners in regard to what is expected of them when working on classroom tasks. This uncertainty leads to extraneous cognitive load.

Keywords: education; extraneous cognitive load; foundation phase; mathematics; physical learning environment; poverty eradication; South Africa; sustainable development; working memory

Introduction

After 20 years of implementing and following a new school curriculum, South Africa still has one of the worst education systems in the world insofar as learner performance is concerned, according to in the Trends in International Mathematics and Science Study ([TIMSS] SA, 2015). In its most recent TIMSS evaluation, South Africa presented at the bottom end out of the 49 countries that took part in the evaluation (TIMSS SA, 2015). The country admits that it needs to take a stern look at its education system, especially since the country is experiencing a crisis in education, specifically with mathematics education (Department of Basic Education, Republic of South Africa, 2015; Spaull, 2013).

A critical factor that influences the future of the 21st century society is the quality of education. In fact, emphasis is placed by educational stakeholders worldwide that the quality of education significantly contributes to the performance of learners in the classroom to such an extent that a lack of quality education is considered to be one of the major obstacles for learners, preventing them from excelling at school (National Education Association, n.d.).

Yearly since 2013, the World Top 20 Organisation (2017) rank countries around the world according to their ability to prepare their youths efficiently for a 21st century global knowledge-based economy. These rankings are compiled from yearly data extracted from six international educational monitoring organisations (the Organisation for Economic Co-operation and Development [OECD]; Programme for International Student Assessment [PISA]; the United Nations Economic and Social Council [ECOSOC]; the Economist Intelligence Unit [EIU]; TIMSS and Progress in International Reading Literacy Study [PIRLS]).

According to the above-mentioned statistics supplied by the World Top 20 Organisation (2017), South Korea, Japan and Russia were the top three countries in 2016 with regard to quality education, and Finland is predicted to be the top country for 2017. Singapore is currently the world's best "test taking" country (World Top 20 Organisation, 2017). How do these top countries view quality education?

These countries view the physical learning environment as crucial for optimal learning (World Top 20 Organisation, 2017). Choi, Jeroen, Van Merriënboer and Paas (2014) explain that the physical learning environment to be a combination of resources used in the learning environment, where elements such as the physical presence of other people in the classroom and sensory stimuli from the environment that can be perceived by human senses, that is, sound or noise.

Finnish classrooms are typically quiet, due to their small class sizes and well-behaved learners, although most of their success is attributed to the design of the learning environment (English, 2013; Sparks, 2012). Finnish schools are designed in such a way that the buildings are clustered, with lots of interior and exterior gathering spaces, with large floor-to-ceiling windows and skylights. As is characteristic of a socio-constructivist approach to teaching and learning (an approach that claims people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences), this kind of environment supports optimal collaboration between teachers and learners and provides ideal spaces for small group activities, as well as quiet spaces for individual learning (Sparks, 2012).

South Korean schools differ to a great extent from the socio-constructivist learning approach of the Finns, since they apply a much more teacher-directed approach, although they experience an equal measure of success. The average number of learners per class in South Korean primary schools is between 20 and 30 (OECD, 2012). Every school in South Korea has high-speed internet and, apart from first and second graders, all grades have digital textbooks to make learning materials more accessible (Dalporto, 2013).

Class sizes are generally small in Russia and this is considered to be one of the factors that contribute to quality education in Russia (OECD, 2012). In fact, this tendency can be observed in most OECD countries, where half of the number of countries (17 out of 33) have less than 20 learners per classroom at lower primary level. Only one country (China) has slightly more than 30 learners in lower primary classrooms (OECD, 2012).

However, many studies over the past decade have indicated that reducing class sizes will not necessarily contribute to higher performance of learners. In fact, findings from the OECD (2012) study suggest that teacher quality is in fact considered more important than class size.

To ensure access to education in this country, the South African government issued the draft "Minimum Norms and Standards," which stated that every school must have a maximum of 40 learners per class (Equal Education, 2016). Many schools in the country, especially in the deep rural areas, experience poor infrastructure, are under-resourced and have, in some cases, up to 70 learners per classroom. However, schools in South Africa that are adequately resourced, and where there appears to be a superior physical learning environment, albeit 40 learners in the class, still struggle with learning and teaching, especially when it comes to mathematics (Department of Basic Education, Republic of South Africa, 2011). This compels us to wonder how factors such as large class sizes, resources, and the general building or environment of the class or school influence learning in South Africa, especially in Grade 1, where the most basic knowledge of mathematics ought to be laid.

The research points out that several factors in the physical learning environment influence the quality of learning and teaching in a classroom. When learners need to concentrate on the tasks at hand, while having to content with elements such as noise from the environment, or ineffective teaching strategies, such as when the teacher cannot render effective support to all learners, these elements impact on the available space in the working memory that controls thinking processes. Scarlett (2015) as well as Shafir (2013:293), explain that noise, when inadequately controlled, can lead to learners experiencing stress. Stress, in turn, impacts on learners' available working memory space. Muijs and Reynolds (2001) add that even a factor such as noise in corridors can influence optimal learning during lesson presentations. When working memory is negatively affected, it hampers the thinking processes, which ultimately decrease optimal learning (Woolner & Hall, 2010).

In view of the South African government's focus on achieving quality education in schools, it is the aim of this article to investigate elements in the physical learning environment that cause extraneous cognitive load. Extraneous cognitive load is a form of cognitive load in the working memory that is extraneous (or ineffective), imposed by information and activities that do not contribute to the processes of knowledge construction and automation, which unintentionally make a task more complex than it needs to be (Paas, Renkl & Sweller, 2004). To demarcate the study, and since mathematics is an area of education that causes the greatest concern for the South African education community, this study will specifically focus on the elements in the physical learning environment that influences teaching and learning during the Mathematics presentations of Grade 1 learners, viz. the age group where formal learning starts to unfold. This article serves as a pointer to the South African government regarding factors in the physical learning environment that influence the quality of education in the early years of schooling, which should urgently be addressed.

Background

With South African learners achieving low rankings in Mathematics and Science, according to the National Center for Education Statistics (n.d.) and TIMSS SA (2015), the necessary question is as to whether there are avenues that still need to be explored in order to improve the poor mathematical performance of the country's primary school learners. As the results from the TIMSS 2011 (National Center for Education Statistics, n.d.) and TIMSS SA (2015) clearly indicate, the problems with the learning and teaching of Mathematics in South Africa start in the earliest years of schooling and this is likely to have a snowball effect that culminates in the end of learners' schooling careers.

A number of studies over the past few years have attempted to contextualise the causes of, and to find viable solutions for the South African crises in education, as described above. Taylor, Fleisch and Shindler (2008) note that the Policy Unit of the Office of the South African Presidency has assessed the outcomes and impacts of policies, programmes and projects implemented by the South African government since 1994, and has concluded that the rapid expansion of the education system has been a root cause of learners' poor academic performance. Taylor et al. (2008) further explain that the country placed a notable focus on access to education for all between 1990 and 1995, but that, in the process, inferior institutions were established, which led to a reduction in the quality of education. The Quality Improvement, Development, Support and Upliftment Programme (Department of Basic Education, Republic of South Africa, 2008) states that a major determinant for underachievement at the majority of schools in South Africa is a lack of the most basic resources (for example, textbooks and other educational equipment), which are essential for the creation of a quality learning environment. At many of these under resourced schools, learners sit on empty maize-meal sacks, beer crates or bricks, sitting doubled over, as they attempt to write in their exercise books.

In 2015, the lack of a proper physical learning environment still seems to be an unresolved and critical issue in South African schools. The South African government is aware of the fact that effective teaching can only take place in a supportive physical learning environment that provides learners with quality learning opportunities. In an attempt to improve quality learning opportunities for learners, teachers in South Africa follow a socio-constructivist approach to learning and teaching (Skosana & Monyai 2013). One of the aims of this approach is to encourage interactive participation, collaboration by learners through communication and sharing of ideas, specifically in mathematics. Although the verbal sharing of ideas and active collaboration form an important part of learning in modern-day classrooms, it does open up possibilities that such an approach could directly impact on learners' cognitive processes (Kirschner, Sweller & Clark 2006; Woolner & Hall, 2010). Furthermore, Woolner and Hall (2010) explain that, in terms of improving classroom climate to make it more conducive for learning, schools need to look into unnecessary noises from the outdoor environment such as noise in corridors. Against this backdrop, the next section will explain the impact that the physical learning environment has on learners' working memory.

Theoretical Framework

A child does not develop in isolation, but through interaction with other people in his or her environment (Vygotsky, 1987 in Gredler & Shields, 2008:155–156). Through interactions with peers, in a classroom that provides learners with active learning opportunities, the child becomes part of the classroom culture, as he or she seeks the cooperation of others when engaging in activities, when reflecting on his or her actions by asking questions; when communicating predictions; clarifying thought processes; and reaching conclusions (Vygotsky, 1987 in Gredler & Shields, 2008:155–156).

As teachers support learners in communicating and sharing ideas, the classroom should be an inviting space that encourages dialogue. Seating should be arranged in such a way that learners face each other, for ease of communication, as well as to encourage interaction with the teacher (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2006:5). Small-group teaching is encouraged, as it enables teachers to render support effectively when and where necessary.

Woolner and Hall (2010) point out that it could be expected that learners, in such a classroom, may become noisy when discussing possible solutions to problems or may move around excessively. In this regard, a study by Marais (2016) points out that learners, particularly in noisy classrooms, cannot pay attention or participate effectively, due to excessive noise levels and, consequently, a general lack by the teacher to handle effective discipline. This is confirmed by Van Tonder, Woite, Strydom, Mahomed and Swanepoel (2015), when they explained that noise levels in the classroom interfere with learners' listening abilities and prevent the benefits of learning that stems from a social learning environment. According to Van Tonder et al. (2015), noise in the physical learning environment may inhibit the cognitive development of young learners in the foundation phase, due to the fact that a learner's ability to recognise and understand speech in an adverse listening environment (such as a noisy classroom) does not mature until the teenage years. Studies from the aforementioned scholars demonstrate that children generally have more difficulty performing cognitive tasks when it is noisy and suggest that noise tends to undermine long-term learning. Yet, much uncertainty still exists regarding how exactly noise interferes with particular cognitive processes relevant to learning (Woolner & Hall, 2010). This can be explained when one considers the effect that the physical learning environment has on the cognitive load of learners' two memory systems, namely the working memory and the long-term memory systems, as discussed by Choi et al. (2014).

Cognitive load theory is a theory of instruction that explains the role of working memory in learning and teaching, and proposes suggestions for effective instruction. There is considerable evidence linking performance in working memory tasks to vocabulary acquisition (Engel de Abreu & Gathercole, 2012) as well as early academic success in reading and arithmetic (Alloway, Gathercole, Kirkwood & Elliott 2009:606; Arndt, Sahr, Opfermann, Leutner & Fritz, 2013; Espy, McDiarmid, Cwik, Stalets, Hamby & Senn, 2004:465–486; Gathercole &

Alloway, 2008; Stevenson, Bergwerff, Heiser & Resing, 2014:2). Furthermore, measurements of working memory ability, taken at the start of formal education, are much stronger predictors of success in reading, spelling and arithmetic than are intelligence quotient (IQ) scores (Alloway & Alloway, 2013:82; Alloway et al., 2009:1). Scholars in the field of cognitive science (Alloway, 2009; Choi et al., 2014; Dehn, 2008; Gathercole & Alloway, 2008; Holmes & Adams, 2006; Paas & Kester, 2006; Paas & Sweller, 2012) explain in their studies how the two major memory systems help humans to acquire, store and retrieve information. From the studies of these scholars, it is clear that the minds of all human beings consist of two basic and essential memory systems, namely working memory system (previously considered to be the short-term memory system – see Archibald & Gathercole, 2006:266) and the long-term memory system. Each system fulfils a distinct and indispensable function in all learning. The following explanation of the relationship between working memory and long-term memory has been compiled from the research studies of the prominent scholars noted above and provides a thorough account of the process of learning in terms of the two memory systems.

Working memory can be seen as a temporary "mental space" in the mind, where information received from the senses is processed and monitored. Long-term memory works in close relation with working memory, and stores an unlimited supply of information received from the working memory system. When working memory passes on processed information (which takes a few seconds at the most) to be stored in long-term memory, long-term memory categorises this information in terms of integrated and related facts, in the form of a schema (Karacapilidis, 2010:71). A schema can be described as "pockets" of related information, for example, our schema for colours. Although the schema comprises one single "idea," it contains all sorts of related information when it is recalled from long-term memory. Once this information is stored in long-term memory, it is always available for retrieval by working memory, whenever necessary. Working memory constantly retrieves previously stored schemata in order to make sense of new information. Although long-term memory has an indefinite capacity for storage of information, working memory has a limited capacity for retaining information, while attempting to make sense thereof.

Several scholars in the field of cognitive load theory (among others, Choi et al., 2014; Leppink, Paas, Van Gog, Van der Vleuten & Van Merriënboer, 2014; Paas & Kester, 2006) explain that there are three types of "loads" that can be imposed on working memory. The first kind is called *intrinsic cognitive load*. This entails the content of the subject and the material itself, for example: 2 + 3 = 5. It is learned (made sense of) in the working memory and cannot be altered (that is, for example, 2 + 3 will always, without exception, equal 5). This kind of load sometimes has a low activity element (meaning that it requires little mental effort, for example, when mathematical vocabulary is learned); or it can have a high activity element (meaning that it requires concerted mental effort, for example, when the number "2" is part of a sentence or word sum: *How many apples will I have if I had 5 and lost 2?*).

The second kind of load that can be added to the working memory is extraneous cognitive load. This refers to unnecessary information that we receive from the environment, which has nothing to do with the learning that needs to take place (e.g., noises occurring in the environment or irrelevant discussions). It is possible, and should be the aim of good teaching, to avoid this kind of load on the working memory. Given that there is already intrinsic cognitive load imposing on the capacity of working memory, extraneous cognitive load only succeeds in overloading the capacity of working memory, thus preventing optimal learning.

The third kind of load imposed on working memory is germane cognitive load. This type of load is necessary, as it contributes to learning; and works in close relation with schema construction in long-term memory, for example, when teachers use diagrammes, flowcharts or flashcards in their presentations. It is important that teachers balance germane cognitive load with intrinsic cognitive load, as these two aspects should stay within the limits of working memory capacity when combined.

Well-prepared learning opportunities, which take the cognitive load on learners' working memories into consideration, ought to lead to optimal learning (Choi et al., 2014). As learners spend long hours at school on a daily basis, teachers should also take into consideration the physical learning environments of their classrooms as unnecessary environmental factors, such as noise, can impact as extraneous cognitive load on the working memory. Scarlett (2015), as well as Shafir (2013:293), add to this by explaining that stress experienced by learners is elevated by all kinds of stimuli in the classroom environment, such as noise, or the availability of teachers to render support. Noise will impact on the working memory of the learners, who are trying to concentrate, as it takes up space in the working memory when these learners try to filter out the noises in the classroom. If learners need to allocate a lot of attention to filtering noise, it will compete with the available space in the working memory that should ideally be reserved for intrinsic cognitive load or germane cognitive load (Choi et al., 2014). Although people can instinctively filter out certain noises (this excludes learners who suffer from learning disabilities related to attention and concentration), the effort still takes up valuable space in the working memory during the filtering process (Choi et al., 2014).

Problem Statement

Goswami, Hassan and Sarma (2018), and Woolner and Hall (2010) have respectively pointed out that classrooms have some inherent noise stemming from road, rail/air traffic as well as playground and building noises. Additionally, there can be other sources of noise such as children walking and talking in the halls, class bells and/or noise from adjacent rooms that add to negative influences on classroom learning (Muijs & Reynolds, 2001; Woolner & Hall, 2010). Large class sizes also add to the inherent noise of classrooms, which is unavoidable in the case where the teaching strategy of the teacher encourages group discussions and interactions with peers (Goswami et al., 2018). One can therefore expect this element of the physical learning environment to contribute to extraneous cognitive load in learners, especially at the foundation phase level, as explained by Van Tonder et al. (2015). Due to large class sizes and factors of the outdoor environment, noise in the physical learning environment ought to be regarded as a distinct causal factor of cognitive load (Choi et al., 2014). Teachers ought to take note of factors that contribute to noise in the physical learning environment that could lead to extraneous cognitive load and should plan the environment in terms of the best possible options for minimising extraneous cognitive load (Muijs & Reynolds, 2001; Woolner & Hall, 2010).

Very little research exists regarding the effects of the physical learning environment on cognitive load and learning (Choi et al., 2014) and, where research does exist, it is inconclusive, contradictory or incomplete (Woolner & Hall, 2010). In view of the need to add to this body of knowledge in the field of research, it is the aim of this study to improve the knowledge of teachers and the research community on the factors of the physical learning environment that influences learning. Also, since the South African teaching community still struggles to find ways to improve primary school education (Human Resource Development Council of South Africa, 2014; Muller, 2016, National Center for Education Statistics, n.d.; Spaull, 2013; TIMSS SA, 2015), it would be worthwhile for this community to pay attention to the physical learning environment of its learners, with the aim of reducing extraneous cognitive load as much as possible.

The knowledge gained from this investigation will therefore be twofold: not only will it contribute towards directing the way forward for education in South African primary schools, but it will also contribute to the currently limited body of information available in this specific research field, that of cognitive load theory.

Methodology

In order to investigate how large class sizes and, subsequently, the noise that stems from it impact on the teaching and learning in foundation phase classrooms, a qualitative approach with a case study mode of inquiry was deemed the most suitable method. In addition, and to elucidate the findings derived from observations, open-ended interviews were held with primary school teachers at a school in the Pretoria central business district, located in the Tshwane West district of the province of Gauteng, in South Africa. This specific location was chosen as the school is more than adequately resourced. For example, the classrooms are equipped with whiteboards, overhead projectors and a number of supportive learning materials for the learners.

Since the school is well-equipped and allows learners to work effectively, either individually or in groups (as suggested by UNESCO, 2006:5 to be the ideal situation for optimal learning), it is understandable that teachers at this school would be concerned about Grade 1 learners' performance, since 17% of Grade 1 learners (20 out of a total of 117 Grade 1 learners) failed the grade the year before. A purposive sampling strategy was followed and it was decided that the researcher would observe the mathematics practices of the four Grade 1 teachers at the specific school, in order to observe if noise and stress may be a causal factor that influences optimal learning in the four Grade 1 classes.

Video-Recorded Classroom Observations

The material necessary for this study was first gathered by means of video-recorded classroom observations. According to Derry, Pea, Barron, Engle, Erickson, Goldman, Hall, Koschmann, Lemke, Sherin and Sherin (2010:15), video recordings, as an aid to observation, are increasingly being used in modern research studies for the benefit of dense information acquisition in terms of real-life human activity. Derry et al. (2010:6) reason that video-recording technology acts as a microscope that enlarges the social situation and allows for the re-examining of data that can be stored permanently for later retrieval. In the case of this study, video-recordings of classroom activity gave the researcher the opportunity to observe inherent noise stemming from the environment, such as noise or sounds from the road, playground, rail/air traffic, as well as building noises. It also lends itself towards observing the influence of class sizes, which also impacts on the inherent noise of classrooms. Although no observation can provide a complete account of the whole classroom situation, video recordings can at least provide trustworthy material, which can then be transformed into data and analysed systematically (Derry et al., 2010:20). It was therefore considered apt in the present instance to utilise video recordings as a means for gathering material for data-rich observations, as the classroom situation, once filmed, can be revisited repeatedly during analysis for the purpose of developing a response to the research question.

Management of Classroom Observations

As the accurate outcomes of observations and the successful gathering of information cannot be guaranteed by means of a single round of observations (Nieuwenhuis, 2010:85), it was decided that provision should be made for at least two observations per classroom by conducting an initial round, followed by a second round, three weeks later. The first round focused primarily on the teachers' lesson presentations, with less focus on learners' participation. The second round was geared towards learners' participation rather than educators' presentation. The separate focus of each observation (the educators and the learners respectively) enabled the researcher to derive the most information from each observation, without being distracted by the need for alternating between educator and learners. The observation sessions were conducted at different times of the day, with a time lapse of three weeks between the first round of observations and the second round of observations. The time lapse between rounds gave the researcher the opportunity to examine the collected data for lacunae. A time limit for each observation session was set between 30 and 40 minutes. This time limit was decided upon so as to avoid imposing an excessive strain on teachers and learners, while nevertheless gathering sufficient information with regard to resolving the problem statement. It was organised with each teacher before each visit where the camera would be positioned in the classroom in order to intrude as little as possible; yet still being able to observe the classroom interaction optimally. With the first visit to each classroom, the camera was positioned at the back of the classroom, more or less 10 m away from the front of the class, where the teacher was standing while interacting with the learners. The video recordings were only conducted during the mathematics presentation, since the focus of the study was on the poor mathematics performance of learners in South Africa. The set-up for the recordings was done before the mathematics presentation started. With the second visit, the camera was placed at the front of each classroom, approximately 10 m from the back of the class. The exact position of the camera differed slightly for each of the classrooms, as the placement of furniture differed in each classroom. However, the fact that the camera could be placed unobtrusively at the front, as well as at the back, of each classroom ensured that the same level of data regarding classroom appearance and sound could be collected.

Interviews with the Grade 1 Teachers

To corroborate the findings from the classroom observations, it was decided to hold a one hour-long interview with each of the teachers. These interviews took place in the afternoon following the classroom observations. The time of the interview was important as it was essential that teachers were relaxed and could focus well on the discussions without any unnecessary interruption. A set of questions was constructed beforehand and given to the teachers three weeks prior to the study in order for them to orientate themselves for the interviews. However, the interviews also gave the teachers the opportunity to elaborate on the interactions that were recorded on video earlier the day.

Data Analysis

Frames of minute-by-minute recordings of the interaction that took place in each classroom were taken and plotted on a coding sheet. In an effort to clarify the factors that cause noise in the learning environment, as set out in the problem statement, the researcher observed instances where noise in or around the classroom could possibly interfere with the learning process when learners were interacting with the teacher or when they were working in groups, pairs or individually.

The minute-by-minute observations of classroom interactions were written down and initially coded with a provisional coded system by the researcher only. The provisional codes were generated prior to the fieldwork from the literature review, the conceptual framework of the study, and the research question; as well as from the pilot study and the researcher's own knowledge and experiences. As the video recordings were analysed, the provisional codes were modified and expanded to include new codes that were not anticipated at the onset of the data collection process. The hour-long videos of the interviews were transcribed and coded systematically by the researcher in the same way as with the classroom video recordings. This provisional coded system, which was later modified to allow for new codes that arise from the data, provided the researcher with the opportunity to contrast and compare the codes in order to find discrepancies and agreement among the data.

In order to achieve the aim of this study, the findings are presented in two sections, namely those findings associated with the observations from the video-recorded classroom interactions and the findings that stem from the interviews with the teachers.

Findings on the Physical Learning Environment Portrayed through Video Recordings

Video observation of the interactions between the teacher and learners holds the possibility that noise can be critically considered as an element of the physical learning environment that has an influence on teaching and learning in classrooms. However, it must be noted that because learners, and to some extent the teachers as well, are aware that they are recorded, they may behave differently than they normally would. This may impact on the outcome of the observation. Although this fact is taken into account, it is the researcher's opinion that the learners would initially be influenced and may either be subdued, or may display "clown-like" behaviour. This possibility was discussed with the teachers, but they were of the opinion that in the event that such behaviour may occur, it would only prevail for a short period of time and that the learners would continue as normal as soon as the newness of being recorded subsided. Also, it was decided that the researcher would be as unobtrusive as possible and would record the interactions from the back of the class. Learners will therefore be seated with their back to the researcher. This issue is, however, considered a limitation of the study.

Teacher One

In this classroom, the seating of learners is arranged in four rows of five twin-seater desks facing the board at the front of the class. This allows learners to be paired with a class friend, with whom they can collaborate in a small-group situation. During the first classroom observation, the teacher followed a step-by-step approach, explaining to the learners what is expected from them with the class book exercise. Learners were allowed to help one another, although the teacher reminded them to try and find the solution to the problem themselves, before turning to a friend for help. With the second round of classroom observations, learners were given mathematical problems to solve in pairs with any of the available resources. The teacher rotated among the learners to provide support where necessary. They then had to enter the sums in their workbooks. Learners had to do a few such exercises. The teacher explained in great detail what was expected of the learners for each section of the task; however, it became evident that the learners were still unsure about what was required of them, as they constantly looked at their peers' work, to the point where their teacher felt it necessary to reprimand them. It was evident from the recordings that learners erased much of their work, as learners were constantly using their erasers to correct what they had written. Learners raised their hands for assistance, but the teacher could not render support fast enough, as some learners, who had their hands up for a long time (about 10–15 minutes), lowered them after a while. One boy, who could not succeed in drawing the teacher's attention, stood up from his desk and left the class without the teacher noticing. He came back after about 10 minutes and sat down again without the teacher being aware that he had left the class. The class became noisy during this exercise and, after a while, the teacher abandoned the lesson to start with other activities.

Teacher Two

In this classroom, the seating of learners is arranged in four rows of five twin-seater desks facing the board at the front of the class. A large carpet is placed at the back of the class, where large-group teaching can be done. With the first visit to the class, the learners were called to the carpet. As there were 40 learners, it was difficult to seat the learners in such a way that everyone could clearly see the demonstration the teacher was about to deliver. As learners found it difficult to see the teacher demonstration clearly, much pushing, shuffling, and moving prevailed throughout the lesson. The teacher demonstrated the principle of odd and even numbers and called several learners forward each time she added a new number. As learners were eager to each be given an opportunity to come forward, they became noisy and the teacher had to reprimand them often in order to be quiet. Some learners at the back of the carpet lost interest, and start playing around.

With the second observation, the teacher handed out the learner books, which took some time. The instruction was given that the learners ought to open their books at a certain page, and the teacher demonstrated on the blackboard what was expected with the exercise. While the learners were working on the exercise, the teacher rotated among the learners, and assisted learners where necessary. Learners were also supported by their peers next to them, or turned to the friends behind them for assistance. The exercise became noisy and the teacher had to settle down the learners several times.

Teacher Three

In this classroom, the learners were seated in five groups of six learners facing each other. A carpet was placed at the front of the class. With both visits to the classroom, the teacher first did a whole-class introduction to the lesson and then called one group to the carpet for small-group work (the groups rotated throughout the math lesson), while instructions were given to the rest of the groups regarding pages they had to complete in their learner book. During the small-group presentation on the carpet, the teacher was obliged to reprimand the other learners – who were busy doing workbook exercises at their desks – to keep quiet several times. As some learners working at their desks worked faster than the others, they became restless and noisy. The teacher told these learners to fetch puzzles, which they could do at their desk. This ended up creating noise, as learners were constantly walking to the puzzle corner to get a new puzzle to complete.

Teacher Four

Due to the small space available in this classroom (it is a rectangular shaped room that was previously used as a music room), the learners could only be placed in long horizontal rows. The teacher did not have easy access to the learners, as the rows were cramped together and she had to present her lesson from the front of the class. With the first visit, the teacher instructed the learners to take five red and three green interlocking cubes for an interactive lesson she was about to present. This exercise took the learners very long (about 10 minutes), as many of them could not locate their blocks or could not count out the correct number of blocks in the colours requested. As the teacher could not easily get access to support the learners, they had to rely on the help of their peers. By the time each learner had the correct colour and number of blocks, many learners were restless and noisy. The teacher struggled to maintain discipline, and was forced to call the learners to order several times.

With the second lesson, the learners had to take out their books to do a step-by-step lesson with the teacher. As some learners worked faster than others, they had to wait a long time (about 5 minutes) before the teacher moved to the next sum. This resulted in the learners becoming restless and noisy. At a point in the lesson, music started to play over the intercom and the principal delivered an announcement. This excited the learners, and they jumped up to dance with the music over the intercom. The teacher struggled to get the learners back to work again.

Noise Related to the Outdoor Environment

Three of the classrooms allow direct access to the corridor, where groups of senior learners passed by noisily each time the bell rang and a transition to the next class took place. The school is built in a square design, and senior learners therefore have to pass the Grade 1 classes every 40 minutes when they go to the next class. Each time, the disturbance resulted in the teachers exiting the classroom to assist with the learners in the corridor before their lessons could continue. It took about 5 to 10 minutes for the noise to subside. In that time, learners in the classroom got up from their seats and moved around or turned around to talk to their peers or started playing around, while waiting on the teacher to continue with the lesson.

Findings on the Physical Learning Environment Portrayed Through Interviews

It was clear from the interviews with all four teachers that the number of learners crammed into the classrooms is seen as a barrier to both teaching and learning. The teachers were of the opinion that the large class sizes impacted negatively on group-work activities (i.e., it caused unnecessary noise); this was to the extent that the teachers, at times, needed to resort to a "one-size-fits-all" approach (also called a "whole-group" approach). All four teachers indicated that, although they would ideally like to follow a small-group approach to the teaching and learning of mathematics, they would be obliged to revert to a whole-group approach, due to the impact that large groups of learners have on their teaching practice. Teachers 1, 2 and 4 explained that when rendering support to individual learners, others would have to wait for further instructions from the teacher, which subsequently opens the door for learners to become noisy. The only option left is to restrict individual support to learners. Teacher 4 explained that, because many learners are not familiar with the kinds of resources supplied for the teaching and learning of mathematics, a great deal of time is usually spent on teaching the learners how to use the resources. This resulted in the teacher having to render individual support to help the learners with the equipment, which subsequently leaves the door open for some learners to become noisy, while others lose concentration on the task at hand when having to wait for a long time for the teacher to continue with the lesson.

However, the teachers explained that in order to keep the continuity in a lesson and to avoid the learners' behaviour to become disruptive, they cannot really give attention to all learners individually during class time. Learners therefore have to draw on the help of peers. Teacher 3 uses a small-group approach, but agrees that this too has its challenges with large classes. When the teacher works with a small group of learners on the carpet, learners from the other groups cannot continue with individual class exercises and becomes disruptive. She often needs to pause her work with the small group on the carpet to maintain order in the classroom.

The study was limited by the number of classroom video observations. Two focused sessions with each of the four teachers and their learners were used for observation purposes. This could be seen as a limitation, since each teacher was only observed presenting the mathematics lessons once. Although the observation of the learners' participation in the lessons were lengthy sessions, the observations consisted of only a single, focused session of each of the four groups of learners.

Discussion

The aim of this study was to investigate the factors of the physical learning environment that impacts on learners' working memory that, in turn, influences optimal learning in classrooms. In terms of the stated aim, analysis of the data suggests that large class sizes and outdoor noises, at the particular school where the study was conducted, are the root causes of distraction during lesson presentations and that this subsequently impacts on the working memory of learners as extraneous cognitive load.

Consistent with the findings of Choi et al. (2014), Goswami et al. (2018) and Woolner and Hall (2010), this study found that the noise from the outdoor environment (caused by learners passing in the corridor) interferes with the lesson presentation of the teachers and subsequently led to the Grade 1 learners' distraction from the task at hand. When the teacher had to pause the lesson for several minutes to tend to the noise outside (this happens approximately every 40 minutes), it resulted in a break in learners' concentration. This leads to extraneous cognitive load and impacts on the optimal learning that should take place.

Secondly, and perhaps most significantly, teachers lack the ability to render the necessary support to learners, due to the large number of learners in each class. As explained by Scarlett (2015), when the teacher cannot render support, learners experience uncertainty and doubt that causes extraneous cognitive load, which ultimately limits optimal learning.

Thirdly, having to pause presentations or support to learners when noise develops, either in the class or from the outdoor environment, causes learners to lose concentration on the task at hand, which impacts on learners' working memory.

Conclusion

Due to the fact that great emphasis is placed on quality education worldwide, this article investigated the contribution of the physical learning environment on the teaching and learning in foundation phase classrooms in South Africa, more specifically the influence of large class sizes and noise in the class. The case study research design was implemented at a well-equipped primary school in the South African province of Gauteng, where 20 Grade 1 learners failed the grade. The findings suggest that the high number of learners in Grade 1 classrooms, coupled with noise from the outdoor environment, negatively influenced the teaching and learning during lesson presentation. Since research has shown that the rate of economic return on pedagogic intervention, as an investment made in the early formative years of a child's life, is significantly higher than for any other stage (Heckman & Masterov, 2007); coupled with the fact that South Africa is facing a dire situation in terms of quality education and, inevitably, towards achieving sustainable development; several recommendations are proposed for the South African education community regarding the avenues that can be explored in the quest for a solution to the education problems that start in the early years of primary education.

Recommendations

This study recommends that South African primary schools attend to the number of learners in Grade 1 classes, as a reduced number of learners per class will contribute to more time for teachers to render individual support to learners, which would contribute to their better performance. The uncertainty experienced by learners as to what is expected of them with their mathematics tasks, coupled with ineffective support rendered by teachers, due to the demands placed on the teacher by the large number of learners in the class, resulting in extraneous cognitive load of the working memories. With a view to reducing extraneous cognitive load, instructional scaffolding methods – where step-by-step guidance is rendered to learners within a whole class set-up – should be looked into as a more appropriate approach to the teaching and learning of Grade 1 classrooms in South Africa. In addition, teachers should be made aware of the impact of noise from the environment on learners' working memory, and should look into strategies to curb unnecessary noise during class time.

This study was limited by the fact that there was no comparison of the classroom practices among the Grade 1 teachers of the specific school in the study with regard to the learning outcomes of each class. It is therefore recommended that comparable studies be conducted in order to contrast different teaching approaches among Grade 1 teachers to the performances of their learners. It is also recommended that comparable studies be conducted among schools with sufficient resources and high learner achievement to the outcomes of this current study.

Ethical Considerations

In compliance with ethical requirements, the authors declare the following:

Statement of human rights

All procedures performed in the study involving human participants were in accordance with the ethical standards of the institution and/or national research committee and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

Informed consent

Informed consent was obtained from all the individual participants included in the study, as well as from parents of the learners who participated in the study.

Authors' Contribution

MN wrote the manuscript. CM contributed to the literature review and verified the data in the empirical investigation and data analysis. MN and CM reviewed the final manuscript.

Notes

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