Research Article

Information Processing Ability and its Implications for Teaching and Learning *

Mariette FOURIE [1] **Gawie SCHLEBUSCH** [2]

Abstract

The aim of this paper is to explore how the brain processes information, and which factors affect the information processing ability of learners in the classroom. From the hierarchical linear modelling (HLM) analysis, it is evident that the independent variables age, home language, language of learning and teaching (LOLT), and average class size affect the information processing ability of learners in the classroom. The process by which the brain acquires, use, and think about knowledge is known as cognition. Cognition are those intellectual or perceptual processes occurring within us that the typical individual would describe as thinking, rational processing, or the mind. Through learning, an individual's cognition develops long-term changes in mental representations or associations because of environmental learning and experiences. A quantitative design was followed to gather data from Grade 11 learners by means of a questionnaire. The results revealed that information processing ability of learners as a dependent variable was significantly influenced by the following independent variables: age, home language, language of learning and teaching, and average class size. Recommendations to teachers on how to facilitate efficient information processing are made, which could result in meaningful learning and understanding by the learners. It is hoped by the researchers that, employing these tactics, will render valid results that are consistent with the need to enhance learners' depth and breadth of processing information, and thereby become sophisticated and complex producers of knowledge.

Keywords: Cognition, hierarchical linear modelling, human memory model, information processing ability, teaching and learning

1. INTRODUCTION

Laxman and Chin (2010) state that the brain is an organ of learning, designed to gather and store an infinite amount of information, and then put it to use. In turn, Fuchs (2011) comment that the brain appears to be the creator of the mind and the experienced world of the learner. Krause, Bochner, Duchesne and McMaugh (2009) refer to the process by which the brain acquires and use knowledge as cognition**.** Cognition encompasses many aspects of intellectual functions and processes to utilise existing knowledge to create new knowledge. Eggen and Kauchak (2014) assert that through learning, an individual's cognition develops long-term changes in mental representations or associations because of environmental learning and experiences. The developmental changes that occur include the construction of thought processes (i.e., thinking, rational processing, or the mind) such as the mental processes of perception, memory, judgment, and reasoning, as contrasted with emotional and volitional processes from childhood through adolescence to adulthood. Ormrod (2008) clarifies that learning, including classroom learning, is largely a mental phenomenon that undoubtedly has its basis in the brain.

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[1] *Dr., North-West University, Quality Enhancement, South Africa, mariette.fourie@nwu.ac.za*

[2] *Assoc.Prof.Dr., Central University of Technology, Department of Post Graduate Studies Education, South Africa, gschlebu@cut.ac.za*

[*] *Corresponding Author e-mail adress: gschlebu@cut.ac.za*

Hurley (2012) says that researchers and psychologists have attempted to search for the engram, the physical trace of memory. Mastin (2018) explains that three brain areas play significant roles in the processing and storage of different types of memories: cerebellum, hippocampus, and amygdala. The cerebellum processes procedural memories; the hippocampus is where new memories are encoded; and the amygdala helps determine what memories to store, and also plays a part in determining where the memories are stored based on whether we have a strong or weak emotional response to the event. Strong emotional experiences can trigger the release of neurotransmitters, as well as hormones, which strengthen memory, so that memory of an emotional event is usually stronger than memories of a non-emotional event (Spielman, Dumper, Jenkins, Lacombe, Lovett, & Perlmutter, 2016). Kim and Lee (2014) state that learners should possess more than simply a quantity of knowledge, i.e., how much they know, instead, learners should possess the abilities to assimilate or accommodate incoming information to existing knowledge in the schemata. The new knowledge would then be constructed, and inadvertently excite teachers' commitment to create an environment that enables the development of information-processing abilities of learners. Information processing ability refers to the ability of learners to process information through the learning process. For meaningful learning to take place, where information is transferred from the working memory to the long-term memory, information processing has to occur (Van der Merwe, 2013). Krause et al. (2009) agrees by adding that the process of brain development is important in the teaching and learning process.

1.1 Learning in an Interactive Teaching-Learning Environment

In a classroom, an effective and knowledgeable teacher is an important school-related factor that facilitates the learning process, and who is responsible for learning (Schacter & Thum, 2004). Sousa (2011) contends that teachers try to change the human brain every day and the more they know how it learns, the more successful they can be. Teachers are in the only profession in which their job is to change the human brain every day. Jensen (2008) postulates that as the brain continues to be the new frontier, the old way of schooling is fading as fast as our understanding of the brain increases, and it is the most relevant understanding for teachers to have.

Grösser (2007) is of the opinion that effective teachers regard how learners learn and subsequently carefully plan instruction towards creating a successful learning environment. Grösser promotes the important role that the teacher plays in developing certain learning functions, which in turn assist the learner in the learning process and in the ideal realisation of learning goals and learning outcomes. These learning functions refer to the manner in which new information is linked to prior knowledge, how to organise information effectively, and how to acquire cognitive learning strategies as well as metacognitive learning abilities. As Kandarakis and Poulos (2008) explain, in terms of the information-processing model, and how learners learn, learning presents the process of gathering information (retrieving it from the environment) and organising it into mental schema. Jensen (2008) explains that brain-based learning or education is best understood in three words: engagement, strategies, and principles; and encapsulates that brain-based education is the engagement of strategies based on principles derived from an understanding of the brain. Teachers who understand how this theory contributes to learners' information-processing ability and that the learning environment has specific effects on academic achievement, select appropriate learning strategies to improve retention and retrieval of learning.

1.2 The Human Memory Model

The structure of human memory was initially proposed by Atkinson and Shiffrin (1968) and is often described in the framework of information processing theory (Eggen & Kauchak, 2014). Woolfolk (2007) elaborates on the information-processing theory by mentioning that processing involves encoding (gathering information and organising it in relation to what is already known), storage (holding information), and retrieval (getting the information when needed). The information processing theory describes how information is perceived from the environment and processed accordingly. Kandarakis and Poulos (2008) assert that learning is defined as the process of acquiring new information, while memory is defined as the persistence of learning that can be accessed later. Consistent with Atkinson and Shiffrin's theory, Hedge (2013) concedes that the memory stores can be functionally divided into three systems, namely: sensory memory (SM), working memory (WM) and long-term memory (LTM).

1.2.1 Sensory Memory (SM)

Eggen and Kauchak (2014) state that SM is important due to the fact that it is the starting point for further processing, where SM holds the information until we attach meaning to it and transfer it to WM. Thus, learning and development depend on experience, and it is a principle of cognitive learning theory, as we acquire experience through our SM. Cherry (2019a) explains that the senses are consistently taking information from the environment and while this information is important, one could simply not remember each and every detail about your experiences. Instead, your SM creates a snapshot of the world around you, allowing you to focus your attention on relevant details briefly. Marchetti (2014) adds that SM is affected by attention and that attention causes information to be transferred to the WM. Different senses have different types of sensory memory. The different types of sensory memory have also been shown to have slightly different durations.

According to Cherry (2019a), in explaining the various types of SM, reference is made to the following.

- Iconic memory is perceived as visual sensory memory and involves a very brief image and lasts for about one-quarter to one-half of a second.
- Echoic memory, also known as auditory sensory memory, involves a very brief memory of sound, almost like an echo. This type of sensory memory can last for up to three to four seconds.
- Haptic memory, known as tactile memory, involves the very brief memory of a touch. This type of sensory memory lasts for approximately two seconds.

The importance of SM and attention in the classroom cannot be overstated. By understanding that certain sensory stimulus has a longer duration than others, teachers can easier select a combination of appropriate content so that learners can draw attention to it. Without attention, teachers cannot teach, as learners will not be able to store information in their working memory (Jaeger, Shipley & Reynolds, 2017).

1.2.2 Working Memory (WM)

Malamed (2010) describes WM as being mentally online. Similarly, Eggen and Kauchak (2014) explain that WM is the workbench of the memory system, the conscious component where our thinking occurs and where we try to make sense of our experiences by linking it to our existing understanding. The working memory applies to real-life tasks inclusive of reading (phonological loop), problem solving (central executive), and navigation (visual and spatial processing) of which all function on a conscious level of information processing. These processes work together in order to be able to process information in the prefrontal cortex (PFC) area of the brain. Eggen and Kauchak (2014) explain that the most important process in learning is to construct meaningful knowledge and it takes place in the memory component that is the most limited. This limitation of the WM is explained by the concept 'cognitive load'. Paas and Ayres (2014) add that cognitive load has certain assumptions, which indicate that human memory is divided into WM and LTM. Schemas represent how information is stored in LTM, and that processing new information results in cognitive load on the WM which affects learning outcomes.

Cognitive load theory (CLT), originally developed by educational psychologist John Sweller in the 1980s, explains the cognitive processes related to learning and strategies that could increase the likelihood of teachers to teach more effectively (Paterson, 2017). CLT identifies three broad categories of thinking, or cognitive loads, (i) intrinsic thinking that derives meaning from new information and how it is connected. Dealing with information not related to what you are learning is called (ii) extraneous thinking. Finally, (iii) germane thinking is building mental models (or schema) that encode the meaning of the information and how it is connected. Hall (2016) contends that teachers should not overlook the role of learning in the classroom and cognitive load could be effectively managed in terms of working memory to aid learning. Similarly, Heick (2017) postulates that learning experiences should be designed in a manner that reduce WM load to promote schema acquisition by being specific, not only about the 'what' and sequence of learning, but also the nature of what is being learned. When, for example teachers effectively interact with learners, questioning skills should be a by-product of automaticity. When employing distributed processing, Eggen and Kauchak (2014) provide the example related to the phonological loop and the visual-spatial sketchpad in WM, whereby they operate independently, meaning that each can perform mental work without taxing the resources of the other. In doing so, distribution of the processing load across the two components takes place, and it suggests that learners could learn more if verbal explanation and visual representation are combined. The visual processor supplements the verbal processor and vice versa. Willis (2012) explains that for young brains to retain information, they need to apply the information. Information learned by rote memorisation will not enter the sturdy long-term neural networks in the prefrontal cortex unless learners can actively recognise relationships to their prior knowledge and/or apply new learning to new situations. According to Willis (2012), teachers should employ brain-based teaching strategies to build executive function in learners which includes providing learners the opportunities to apply learning, introduce activities to support the development of the executive function, and to model higher thinking skills inclusive of judgement, prioritising, setting goals, providing self-feedback, and monitoring progress, prior knowledge activation and transfer opportunities, and metacognition.

1.2.3 Long-term Memory (LTM)

McLeod (2010) explains that long-term memory (LTM) is the final stage of the information processing model proposed by Atkinson and Shiffrin (1968) and provides the lasting retention of information and skills. Krause et al. (2009) further explain that the LTM takes on many forms and is broadly divided into explicit (or declarative) and implicit (or procedural) knowledge. Mastin (2018) explains that declarative memory ('knowing what') is memory of facts and events and refers to those memories that can be consciously recalled (or 'declared'). It is sometimes called explicit memory, since it consists of information that is explicitly stored and retrieved, although it is more properly a subset of explicit memory. Procedural memory is referred to as implicit memory because previous experiences aid in the performance of a task without explicit and conscious awareness of these previous experiences, although it is more properly a subset of implicit memory. According to Reisberg (2013), cognitive psychologists, as well as teachers have a shared goal in understanding how to promote long-term learning and memory. Reisberg (2013) further asserts that performance during learning is a poor predictor of future performance because it reflects the momentary accessibility of knowledge (i.e., retrieval strength) rather than how well it has been stored in memory (i.e., storage strength). Learners simultaneously process information on many different levels. At the most basic level, incoming information is processed by the nervous system to organise and understand sensory input. At higher levels, the information is processed with respect to existing knowledge in order to extract meaning. Busch (2017) avers that the ability to retain and recall information is central to improving memory, knowledge, and learning. He postulates that the main findings in a study conducted by researchers from various international universities revealed that practice testing and distributed practice were rated as being very effective for improving LTM (Busch, 2017).

1.3 Cognitive Processes as a Component of Human Memory

In view of the reciprocal relations between cognitive neuroscience and cognitive models, cognitive neuroscientists study how the brain implements cognitive processes, such as learning and understanding neural mechanisms could provide insight into models of cognition (Forstmann, Wagenmakers, Eichele, Brown, & Serences, 2011). Visser (2018) agrees that teachers need to teach for engagement and from education literature it becomes evident that learner engagement is a prerequisite of learning, and for learning to be truly meaningful, learners have to be cognitively engaged. Van Amburgh, Delvin, Kirwin and Qualters (2007) postulate that the concept of learner engagement and active learning is becoming more than just educational rhetoric. Active learning techniques have emerged as strategies for teachers to promote engagement with both discipline material and learning. Cognition is central to the development of psychology as a scientific discipline (Huitt, 2006). Cognition is a rather general term that refers to all mental processes, such as perception, thinking, memory, motivation, attention, emotions, the ability to understand the intentions and thoughts of other people, decision-making, and self-awareness (Cherry, 2019b). Mastin (2018) avers that the overall process involved in the different stages of memory formation is referred to as cognitive processes of attention, perception, encoding, storage, and retrieval.

1.3.1 Attention

The process of memory formation starts with attention that is regulated by the thalamus (Mastin, 2018). Nketsia (2013) defines attention as a cognitive process referred to as an awareness in a perceptive manner as well as the ability to choose and concentrate on relevant stimuli adapted from the environment. When regarding the neuroanatomy of attention. Cherry (2018) further explains that attention is limited, selective and a basic part of the cognitive system. When discussing the neuroanatomy of attentional systems, Petersen and Posner (2012) distinguish between three systems, the RAS, PAS and AAS.

- Reticular Activating System (RAS) or Alert System: this system is mainly in charge of arousal and sustained attention. It is closely related to the reticular formation and some of its connections, like the frontal areas, limbic systems, the thalamus, and the basal ganglia. Gupta (2017) explains that your RAS, actually located in the brain stem, takes a leading role in determining what is important and what is not when it comes to paying attention to various stimulations.
- Posterior Attentional System (PAS) or Orientation System: this system is in charge of focused attention and selective attention of visual stimuli. The brain areas related to this system are the posterior parietal cortex, the lateral pulvinar nucleus of the thalamus, and the superior colliculus.

- Anterior Attentional System (AAS) or Execution System: this system is in charge of selective attention, sustained attention, and divided attention. It is closely related to the prefrontal dorsolateral cortex, the orbitofrontal cortex, the anterior cingulate cortex, the supplementary motor area, and the neostriatum (striate nucleus).

Attention is limited in both capacity and duration and attention is easily distracted. Attention is considered as a departure point of learning, and therefore attracting and maintaining learners' attention is essential for effective information processing (Curtindale, Laurie-Rose, Bennet-Murphy, & Hull, 2007). Rather than engaging learners through passive listening during a presentation, active involvement in learning activities is therefore essential. Some researchers claim that attention precedes perception, and that attention is necessary for perception. This entails that without attention, a human has no conscious awareness of sensory information (Bridewell & Bello, 2016).

1.3.2 Perception

The perceived sensations from environmental stimuli are decoded in the various sensory areas of the cortex, where the hippocampus is responsible for the combination of these into one single experience and the transferral into the LTM (Mastin, 2018). The hippocampus is the regulator where these experiences are compared and associated with prior knowledge or experiences and memory consolidation takes place. Accurate perception in learning activities are essential due to the fact that learners' perception of what they see and hear enter the working memory which implies that if these perceptions are inaccurate, the information ultimately stored in the long-term memory will also be inaccurate (Eggen & Kauchak, 2014). To ensure that learners accurately perceive the information, which is presented to them during a lesson presentation, teachers should establish prior knowledge and actively engage learners in the learning process.

1.3.3 Encoding

After learners attend to and perceive information, having information organised in the working memory as to make sense of it, the next step involves the encoding of information (Eggen & Kauchak, 2014). Encoding refers to the representation of information in the long-term memory. Encoding is a biological event, and it begins with perception through the senses. Meaningful encoding connects new information to information already stored in the long-term memory and to enhance encoding successfully, teachers should carefully organise the information presented to learners together with cognitive activity with interactive teaching strategies. Schellenberg, Negishi, and Eggen (2011) explain that encoding strategies refer to learners' conscious attempts to encode information into long-term memory in ways that are meaningful to the individual. Four encoding strategies include:

- *Organisation:* an encoding strategy that involves the clustering of related items of content into categories that illustrate relationships (Mayer, 2008).
- *Schema activation:* a strategy that involves activating relevant prior knowledge so that new information can be connected to it (Mayer & Wittrock, 2006).
- *Elaboration:* the process of increasing the number of connections among items of existing knowledge (Terry, 2006).
- *Imagery:* the process of forming mental pictures (Schwartz & Heiser, 2006). Learners who consciously use encoding strategies are mentally (cognitively) active as they make decisions about how to make the information they are studying as meaningful as possible.

In contrast, simply reading a textbook, or memorizing information can be a passive process.

1.3.4 Rehearsal

Snowman and McCown (2015) contend that a severe limitation of WM means that information is quickly forgotten in the absence of further processing. Learners can only assign meaning to new learning if adequate time is allowed for processing and re-processing of new information, a process that is referred to as rehearsal (Sousa, 2011). There is almost no long-term retention of cognitive concepts without rehearsal as it is a critical component in the transference of information from WM to LTM. Cognitive psychologists have found it useful and necessary to distinguish between two types of rehearsal: maintenance rehearsal and elaborative rehearsal (Snowman & McCown, 2015). Maintenance rehearsal is mostly effective at placing information in your short-term memory (such as a phone number) while elaborative rehearsal may be more effective at encoding it into your LTM (Heerema, 2018). Sousa (2011) elucidates that maintenance rehearsal or rote rehearsal is the process that is used when the learner needs to remember information exactly as it is entered into WM. This is not a complex strategy, yet necessary to learn information or a cognitive skill in a specific form or sequence, e.g., remembering a poem, the melody of a song, multiplication tables and telephone numbers – all steps and procedures. Elaborative rehearsal is a method to encode information into your LTM by requiring the brain to process it in a more in-depth way. Elaborative rehearsal consists of making an association between the new information you are trying to learn and the information you already know (Heerema, 2018). Elaborative rehearsal can involve organising the information, thinking of examples, creating an image in your head of the information, and developing a way to remember the information through a mnemonic device. Several mnemonic devices can facilitate elaborative rehearsal, such as using the first letter of a list of words to make a new word.

1.3.5 Retrieval

Wolfe (2018) explains that learning is the act of making (and strengthening) connections between thousands of neurons forming neural networks or maps, while memory is the ability to reconstruct or reactivate the previously made connections. So, when we learn something new, we are actually creating new connections between our neurons. And when we want to remember something, we call on those neurons to become activated so we can recall what we have learned before. Without retrieval, a stored memory would have no useful purpose. Sousa (2011) postulates that the brain uses two methods to retrieve information from the LTM, referred to as recognition and recall. Recognition matches an outside stimulus with stored information, e.g., multiple-choice questions. Recall on the other hand describes the process whereby cues of hints are sent to the LTM, which must search and retrieve information from the long-term memory, then consolidate and decode it back again to WM.

Cherry (2018) further explains that the process of retrieval involves accessing stored memories by means of a retrieval clue. She further elaborates that there are four basic ways to retrieve information from LTM and they include recall, recollection, recognition, and relearning. Stanfield (2018) highlights that in order to strengthen memories, they must be accessed repeatedly. Memory is constructive, therefore each time you access and bring out a memory, the easier it becomes to access it in the future as more neural pathways are created and the memory becomes stronger. As teachers, we can encourage our learners to access memories by guiding them to actively recall or retrieve information. This can be done in various ways, including assessment discussion and feedback.

1.4 Metacognitive Processes as a Component of Human Memory

The human information-processing model is regarded as logical, sequential, and largely governed by metacognition (Eggen & Kauchak, 2014). Metacognition refers to a person's awareness of and control over the way information is processed (Meltzer, Pollica, & Barzillai, 2007), and encoding is the process of representing information in long-term memory (Anderson, 2007). Research indicates that metacognition has an important influence on the way learners learn, in general, and encode information, in particular (Pressley & Hilden, 2006). Learners who make conscious attempts to encode information consistently achieve higher than those who are less metacognitively aware (Kuhn & Dean, 2004). Bada (2015) suggests that new, innovative, and creative ways are needed to engage learners in active and meaningful learning experiences to foster and promote the development of critical thinking skills. Wilson and Conyers (2016) assert that teaching learners to become more metacognitive, equips them with skills to drive their own brains and become self-directed learners. Haukas, Bjorke, and Dypedahl (2018) confirm that many studies recently indicated the benefits and effectiveness of metacognition in education, which implies the psychological study of the essence of the mind, form a scientific point of view. According to neuroscience, metacognitive functions are located in the most modern part of the brain: the cerebral cortex. Blake (2016) asserts that learners receiving instruction on metacognition develop skills that will make them more successful in their academic and professional careers.

2. METHOD

2.1 Research Type

The study resided within the post-positivist research paradigm, which Creswell (2013) defines as the successor of 'positivism' theory. Positivism contests the traditional notion of the absolute truth of knowledge. Post-positivism recognises that we cannot be positive about the claims of knowledge when studying the behaviour and actions of human beings. The study followed a quantitative design, investigating the relationship among dependent and independent variables. The dependent variables were measured, typically on instruments, so that empirical data could be analysed using statistical procedures. The purpose of using a quantitative design in this study is mainly to have gained an understanding of the underlying perceptions of respondents, getting insights into how positive psychology could contribute to learner well-being in the classroom, and formulating hypotheses to uncover the prevalent trends, ideas and opinions of respondents. The quantitative research instrument (questionnaire employed), ensured objectivity, generalisability and reliability, as well as ensuring that the researchers became external factors to the actual study. A non-experimental design (survey method) investigating complex relationships among variables by applying techniques of Hierarchical Linear Modelling (HLM) was employed.

2.2 Population and Sample

The target population of this study was Grade 11 learners in the Fezile Dabi Education District, Free State province. A probability, multi-stage cluster sampling procedure was conducted to select a sample for the study. The sample consisted of 650 Grade 11 learners that represented 20 of the 65 schools in the district.

2.3 Data Collection

A questionnaire was employed for data collection. The questionnaire consisted of two sections. Section A contained the demographic variables of the sample (consisting of 20 questions) and section B comprised 80 questions ranging on a four-point Likert-type scale from 'strongly disagree' to 'strongly agree'. The demographic variables also represented some of the independent variables of the study reported on in this article and inlcude age, home language, language of learning and teaching (LOLT), learners' average obtained, and average class size. Section B of the questionnaire was further divided into sections representing the dependent variables (DVs) of the study as confirmed by exploratory factor analysis. These dependent variables inlcude the information processing ability of earners, cognitive engagement, metacognitive engagement, and conscious awareness (i.e., focused attention) during the learning process. For this paper, the researchers only reported on information processing ability as a dependent variable.

2.4 Data Analysis

Issues pertaining to the validity and reliability of the questionnaire were addressed during the research. The validity of the questionnaire was ensured by conducting an exploratory factor analysis. Only items that had a regression weight of above 0.3 were selected for the final questionnaire. The reliability of the questionnaire items was measured conducting a Cronbach's alpha with software program SPSS Statistics. Frequency tables and graphs were drawn with SPSS Statistics software to project the pictorial version of the data using descriptive statistics to obtain measures of central tendencies such as frequency distributions, means, standard deviations and percentages. A quantitative data analysis was done by computing inferential statistics. Hierarchical Linear Modelling analysis was part of the inferential statistics done in the SPSS statistics package. Null-hypotheses were formulated to test statistical relationships between the independent and dependent variables of the study.

The researchers employed hierarchical linear modelling (HLM) to test the relative influence of the independent variables on the dependent variables. The HLM is defined as a generalisation and extensions of regression analysis model. HLM is also developed from Analysis of Variance (ANOVA) inferential statistics. It is in this regard that the HLM model explains variability across levels (Raudenbush & Bryk, 2002). HLM was employed because of its advanced computational capability to handle the nested nature of the data with learners nested in schools. These ANOVA-type HLMs were performed using IPA as dependent variable to assess whether the scores predict unique variance following the hierarchical nature of the data.

Each analysis took the same form, with school (independent variable) entered as subject (school) and biographical variables as factors. The HLM test indicated *statistically significant differences* in the dependent variables IPA across the specified levels of the independent variables. The respondents indicated their agreement with the items using a four-point Likert-type scale ranging from 1 (strongly disagree) to 4 (strongly agree). The independent variables for the study were age, home language, language of learning and teaching (LOLT), average obtained, and average class size. The dependent variable for the study included information processing ability (IPA). The HLM null hypothesis formulated refer to:

- There is no significant statistical difference between age and IPA
- There is no significant statistical difference between home language and IPA
- There is no significant statistical difference between LOLT and IPA
- There is no significant statistical difference between average obtained and IPA
- There is no significant statistical difference between learners' average class size and IPA

3. FINDINGS

This section discusses the results of the HLM null hypothesis.

3.1. Results of the Hierarchical Linear Modelling (HLM) null-hypotheses

Hypothesis 1

There is no statistically significant difference between ***age*** and IPA. Age was a significant predictor of IPA as obvious from F (635) = 2.681, $p < 0.05$ (0.031), $d = 0.378$. ***Therefore, the null hypothesis can be rejected.*** As identified during the *post hoc* test and testing the ES, the difference is evident between ages 17 and 19, with a small to medium ES (d) of 0.378. The highest level of agreement was reported for the age group 15 (M=3.454, SD=0.196), followed by the 19+ age group (M=3.419, SD=0.105); and the lowest level agreement was reported for the age group 16 (M=3.127, SD=0.082).

Hypothesis 2

There is no statistically significant difference between ***home language*** and IPA. Home language was a significant predictor of IPA as obvious from F (541) = 5.098, $p < 0.05$ (0.001), *d* = 0.354; 0.590; 0.601. ***Therefore, the null hypothesis can be rejected.*** As identified during the *post hoc* test and testing the ES, the difference is evident between the languages Afrikaans and Sesotho (*d* = 0.354), Afrikaans and IsiZulu (*d* = 0.590), and Afrikaans and English (*d = 0.601)*. This implies that learners speaking Afrikaans at home compared to learners speaking Sesotho at home differ significantly whereas the effect/strength of the difference reported 0.354 (small to medium effect). The respective effect/strengths of the difference between Afrikaans and IsiZulu is 0.590 (medium effect), and between Afrikaans and English 0.601 (medium to large effect). The highest level of agreement was reported for the home language group English (M=3.458, SD=0.146), followed by the IsiZulu group (M=3.444, SD=0.120); and the lowest level of agreement was reported for the Afrikaans group (M=3.000, SD=0.075).

Hypothesis 3

There is no statistically significant difference between ***LOLT*** and IPA. LOLT was a significant predictor of IPA as obvious from F (234) = 17.177, $p < 0.05$ (0.001), *d* = 0.440. ***Therefore, the null hypothesis can be rejected.*** The strength of the difference between learners with English as LOLT and Afrikaans as LOLT measured 0.440 which indicate a medium ES (*d*). The highest level of agreement was reported for the English LOLT group (M=3.308, SD=0.067), and the lowest level of agreement was reported for the Afrikaans LOLT group (M=2.977, SD=0.078).

Hypothesis 4

There is no statistically significant difference between ***average class size*** and IPA. Average class size was a significant predictor of IPA as obvious from F (322) = 4.028, $p < 0.05$ (0.008), *d* = 0.800; 0.720; 0.902. ***Therefore, the null hypothesis can be rejected.*** As identified during the *post hoc* test and testing the ES, the difference is evident between the below 20 and 20-30 class size (*d* = 0.800), below 20 and 30–40 (*d* = 0.720), and below 20 and 40+ (*d* = 0.902). This implies that learners in classes below 20 learners and learners in classes of between 20–30 differ significantly whereas the effect/strength of the difference reported 0.800 (large effect). The respective effect/strengths of the difference between classes below 20 and classes between 30–40 is 0.720 (large effect), and between classes below 20 and classes of 40+ is 0.902 (very large effect). The highest level of agreement was reported for the 40 + group (M=3.334, SD=0.117), followed by the 20–30 group (M=3.236, SD=0.091); and the lowest level of agreement was reported for the below 20 group (M=2.625, SD=0.190).

4. DISCUSSION and CONCLUSION

The aim of this paper was to explore how the brain processes information, and which factors affect the information processing ability of learners in the classroom. From the hierarchical linear modelling (HLM) analysis, it is evident that the independent variables age, home language, language of learning and teaching (LOLT), and average class size affected the information processing ability of learners in the classroom. As derived from the above hypothesis testing, IPA as a DV was significantly influenced by the following IVs: Age, Home Language, LOLT, and Average Class Size. Learners were of the opinion that Age was a significant predictor of IPA. This entails that learners felt that their information processing ability is strongly influenced by their age. The post hoc test revealed a medium strength difference between the learners aged 17 and 19. In discussing Age, 34% of learners were older than 17, which imply that these learners had repeated a grade at some stage in their high school career. The significance test further revealed that Home Language was a significant predictor of IPA. This means that learners are of the opinion that their home language influences their information processing cognitive engagement in the classroom. The post hoc and Cohen's d tests indicated that there was a relatively large difference evident between Sesotho-speaking learners and Afrikaans-speaking learners.The hypothesis testing indicated that LOLT, as an independent variable, had a significant influence on IPA, which implies that learners feel that their information-processing ability in the classroom is greatly affected by their LOLT. The post hoc test revealed that a relatively large difference was evident between learners who have English as their LOLT in comparison to learners who have Afrikaans as their LOLT. According to learners, IPA is greatly influenced by their average class size. This means that learners attribute their information processing ability in class to how many learners are present in the class. The post hoc test revealed that learners in classes of less than 20 learners in the class differ significantly from learners in classes with over 30 and 40 learners.

Over the years of teaching and the concomitant experience that has evolved into ideas and compounded into an ideology about teaching and learning; the researchers tenaciously hold the view that education is not a neutral phenomenon. It is an ideology, with ideology conceived as a terrain on which people move and acquire consciousness of their position. It is proper to indicate that, precisely because education is ideological and an important mechanism for shaping societal values; teachers should not be left out but be at the front and centre of educational diffusion in schools as the vital part of teaching and learning. Whitman and Kelleher (2016) aver that teachers are brain changers. The researchers agree with the postulation of Whitman and Kelleher and are further of the opinion that teachers are indeed not neuroscientists, but surely regarded as brain changers. The researchers base their opinion on the fact that teachers are in one of the few professions that are responsible to change the brain daily and should therefore perhaps have a basic understanding of how the brain learns. This agrees with the statement of Tokuhama-Espinosa (2018) 'Teachers do more experiments in a day than a neuroscientist does in a lifetime'.

This paper conceptualised information processing ability of learners as the ability to learn. Efficient information processing would result in meaningful learning and understanding by the learners. Since various factors affect the learning ability of learners, recommendations to teachers on how to facilitate efficient information processing first and foremost include having a basic understanding of how humans learn, i.e., how the brain process information. Secondly, the researchers argue for a neuropedagogical approach to teaching and learning. Neuropedagogy is explained by Betts and Fourie (Fourie et.al., 2019) as 'an interactive and transdisciplinary approach to art of teaching and science of learning that builds upon the learning sciences, Mind, Brain, and Education science, and the concepts of neuroplasticity and neurodiversity; targeting and facilitating educational and real-world experiences through responsive curricula, instructional practices and design, active learning, assessment, and feedback to support comprehension, application, and transfer of learning across educational modalities (classroom, hybrid/blended, online) to meet the needs of all learners'. A neuropedagogical approach to teaching and learning could result in meaningful learning and understanding by the learners. It is hoped by the researchers that, employing these tactics, will render valid results that are consistent with the need to enhance learners' depth and breadth of processing information, and thereby become sophisticated and complex producers of knowledge. As Blakemore and Frith (2008:118) explain "We know a little of what goes on in the brain when we learn, but hardly anything about what goes on in the brain when we teach."

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