

A Dialogue between Piaget and Vygotsky on the Developmental Acquisition of the Notions of Necessity and Possibility: A South African Case Study

by

Azwihangwisi Muthivhi

School of Education

University of the Witwatersrand

Azwihangwisi.muthivhi@wits.ac.za

Abstract

Piaget's theory of development, and the acquisition of operational forms of thinking in particular, has had an enormous influence on educational thinking in South Africa over the past decades. Piagetian experimental tasks were replicated in an attempt to understand the psychological sources of the challenges that children experienced during school learning. The present paper reports on the results of the experiment on children's development and acquisition of the notions of necessity and possibility in the course of their schooling.

The results of this experiment confirm that children in non-industrialized settings manifest different forms of performance on the Piagetian tasks from children in industrialized and 'westernized' sociocultural settings. The explanation for this difference is however not to be found in notions of 'cognitive lag' or assumptions of 'cultural deficit', as has in the past been suggested.

The present paper suggests that the Piagetian interpretive framework could productively be linked with the Vygotskian framework to provide a more adequate and comprehensive account of children's acquisition, development and functioning of operational forms of thinking in specific sociocultural settings. This approach provides new insights into the complexities of non-industrialized and 'non-westernized' children's school learning and cognitive development.

Key words: *South Africa, Venda, Piaget, Vygotsky, sociocultural, cognitive development, necessity, possibility.*

INTRODUCTION

The present paper, using the results of the empirical study conducted in a predominantly rural and non-industrialized socio-cultural setting of formal schooling in Venda, South Africa, links the theories of learning and development derived from Piaget and Vygotsky respectively to understand current educational problems in post-apartheid South Africa. Piaget's theory has always had an influence on educational practice in South Africa, especially in regard to the insight that the theory provides about development and learning performance capabilities associated with the various stages that it posits for educators.

Children's performance on Piagetian tasks was often viewed as a simple manifestation of their spontaneous developmental capabilities. While this may generally be the case, the present study presents the results of children's performance on neo-Piagetian task, suggesting that performance results cannot be viewed as simple manifestation of underlying spontaneous developmental achievement but as simultaneously manifesting cultural developmental processes. That is, task performance, and problem solving generally, manifest the structure of culturally acquired knowledge and social relations as proposed in Vygotsky's theory at the same time that they manifest the underlying spontaneous developmental processes posited by Piaget.

This relationship and complementarities between the two theoretical frameworks are addressed through an analysis of the neo-Piagetian experimental task about the acquisition and development of the notions of possibility and necessity. Such analysis emphasizes a dialectically complementary approach, which it could be argued, was in fact present in Vygotsky's methodological proposals from the beginning. As a result, it is further argued that Vygotsky's framework was never intended as a dialogically oppositional approach to Piaget's framework in the first place, but a complementary approach for explaining a common psychological phenomenon:

We [...] are convinced that the study of thought development in children from different social environments, and especially of children who unlike Piaget's children [...], must lead to results that will permit the formulation of laws having a much wider sphere of application (Vygotsky,1986: 56).

Vygotsky critiqued Piaget's theoretical formulation primarily for not taking adequate account of the socio-cultural processes and the crucial role they play in the development of psychological processes. The question that continues to persist in today's thinking about this debate is how much influence sociocultural processes have on psychological development and functioning. Piaget suggested that these have an equal impact with the other explanatory factors such as maturational processes and experiential factors

(Piaget, 1964). Vygotsky ascribed overarching role to the socio-cultural factors, arguing that they generate and determine the course of the higher forms of the specifically human psychological processes (Vygotsky, 1986; 1981; 1978).

The two frameworks, rather than viewed as contradictory, should be viewed as complementary. That is, while the analytic approach in the two frameworks may seem contradictory, one emphasizing the inner-generated 'equilibratory' processes while the other emphasizing the outer-generated 'socioculturally mediated' processes, the differences may in fact be only superficial. This paper will argue, proposing a 'synthetic' analytical approach using insights from both theories that Piaget's and Vygotsky's interpretive frameworks are compatible and could be used complementarily to understand psychological development and functioning.

Contextual background to the present study

In South Africa, especially in the 1990s, there has been enormous interest within developmental psychology scholarly circles on the potential of the discipline to illuminate on the then pressing problems of schooling, more specifically the problems of poor academic performance among Black African students within the country's schooling system.

Most of the studies in developmental psychology applied either Piaget or Vygotsky's framework or both, in the quest to address the practical problems of poor academic performance and the perceived cultural-psychological differences between the more Westernized, mostly White children on the one hand and the mostly indigenous Black African students on the other hand. The studies that emphasized Piaget's framework have mostly suggested the source of poor academic performance among the culturally diverse African students as their diverse sociocultural circumstances, a diversity that produced an apparent 'lag' in pupils' cognitive development and functioning or accounted for their differential and therefore poor performance on experimental tasks and schooling (Macdonald, 1987; Craig, 1989a; 1989b). Most of these studies made recommendations that were consistent with the majority of the Piagetian studies that suggested that non-Western children manifested a lag in their performance on the Piagetian tasks (for details see, Buck-Morss, 1975; Dasen and Heron, 1992).

However, for some South African developmental psychologists, Vygotsky's tradition offered a possibility for overcoming explanations that located the performance of culturally different children perpetually on a hind leg. Vygotsky's framework suggests that cultures are different but transforming towards a common (socio-historical) goal and that the culturally different forms of performance on tasks could be addressed by an introduction of appropriate educational interventions (Matusov, 2007; Craig and Miller, 1984; Moll, 2004). That is, performance is not solely dependent on internally

determined and spontaneously occurring developmental processes, but also on appropriately organized forms of educational interventions.

Most South African studies that applied Piagetian and Vygotskian frameworks have tended to integrate these approaches but such integration seems to suggest that the one theory—Vygotsky's, only came in where the other, namely; Piaget's theory, was not capable of providing an adequate explanation (Craig, 1987). This approach, although it employs both frameworks as complementary, seems to suggest a view of the two theoretical traditions as dialogically opposed. That is, a view that one framework, in itself, fails to provide an adequate account of the phenomena to be explained and as a result needs to be complimented by the other. Therefore, because of this apparent internal theoretical deficiency, additional concepts could be applied in a way of remedying the inherent limitations of the other. The present paper argues that the two theoretical paradigms may be understood as adequate for their explanatory purposes but that they necessarily need each other for understanding human learning and psychological development in its complexity. In what seems to suggest the former view, Craig, for example, argues that:

[...] The 'knowing subject' viewed as an active, purpose-seeking instrument of praxis (from the Piagetian paradigm in cognitive studies) and the internalized, historically and culturally rooted, social forms, communication, and symbols (from the Vygotskian paradigm in cognitive studies) become a legitimate explanatory focus in an analysis of the necessary conditions for change (Craig, 1987: 78).

The present study therefore seeks to unravel the nature of the conceptual relationship that should characterize the interpretation of task performance, based on a synthetic approach to using the Piagetian and the Vygotskian conceptual systems. This dialectically complementary approach, in which the theoretical contributions of the two research and theoretical traditions are used in the interpretation of task performance in the present study, is captured by the metaphor in the title of the paper of a dialogue between the two theoretical traditions. The subject's active and purposive task performance is viewed as inextricably intertwined with, and as occurring through, the 'internalized' sociocultural processes through which human action is mediated.

Theoretical Background

In South Africa, experimental studies have often found that subjects within the "non-Western", non-industrialised and non-schooled communities (and mainly Black children) generally perform poorly on tasks, or lag behind their White or more westernised counterparts (Moll, 1994; Craig, 1985; Macdonald, 1987; Kok, 1986). For example, Craig (1985) conducted a study looking into the cultural origin of the dyadic patterns between Zulu mothers and their pre-school children. In this study, Craig found that the dominant interactional

structure followed a culturally derived pattern. For example, Zulu mothers in the study demonstrated what is referred to as the "field dependent behaviour" whereby children were expected to do global imitations of the mothers' models (Craig, 1985). This instructional method may be deemed as constituting an inefficient problem-solving strategy within a western socio-cultural setting.

Macdonald (1987) conducted an experimental study that also suggested poor task performance by indigenous Black-African children. In this study, Macdonald replicated Pieraut-Le Bonniec's (1980) neo-Piagetian study of the development and use of propositional (hypothetico-deductive) reasoning in primary school children. Following Pieraut-e Bonniec's work, Macdonald's study investigated pupils' understanding of the notions of "possibility" and "necessity", as psychological states that demonstrate the acquisition of formal operational thinking.

Pieraut-Le Bonniec (1980) found that children's ability to maintain uncertainty, in relation to undecidable situations, that is, situations that enable them to think in terms of what is possible rather than in terms of what is empirically real, emerges at about ten years of age. By this age, Pieraut-Le Bonniec's children were able to differentiate with regard to experimental situations between instances where information for making a decision is lacking to cases where the information is complete to give judgement. That is, they were able to perceive and to distinguish between situations where something was "possibly the case" to where something was "necessarily the case". Macdonald (1987b) also found the same with regard to the South African "multicultural" school pupils in her study. Conversely, pupils from the "township" schools in Macdonald's study manifested an apparent developmental lag and did not perform competently on the tasks.

Macdonald's study compared South African pupils across different cultural-linguistic contexts of schooling involving Black township schools¹ on the one hand and the predominantly White "multicultural" schools that had begun to admit Black pupils on the other hand. The comparison extended internationally to the results obtained in a similar study with the Scottish children (Macdonald, 1987). Macdonald's study reports on the sample of 60 subjects from the multicultural school and 28 from the township school. The results of the Grade Five subjects (average age of 10 years) across the two South African school contexts were most telling in that the performance of the South African township children were found to be at the level below that at which the 'multicultural' children (as well as Macdonald's Scottish and Pieraut-Le-Bonniec's French children respectively) performed. The Sepedi speaking, township children in particular only managed to obtain (by Std. 3 or Grade Five) 51% score against 83% of the multicultural school learners.

1 These are schools situated in Black urban reserves established by the apartheid government as exclusive residential areas for Black people.

The results of Macdonald's study and the suggestion of a deficit hypothesis pertaining to the culture and schooling of Black children has inspired the current study to seek a better understanding of the nature of the problems that lead to such a poor performance. The first step toward such an understanding was to replicate the neo-Piagetian experimental tasks on the basis of which the poor performance suggestive of a cognitive lag was established. To understand the nature and source of the modes of performance on the tasks, the Piagetian interpretive framework is complemented by the Vygotskian framework, which permits for a consideration of the possibility of the cultural processes and their influence on psychological development and functioning.

From this consideration, the cognitive performance of the subjects on the experimental tasks is analysed in relation to the cultural activities that inform such performance rather than only in relation to the internal, individual developmental processes. Without denying the importance of children's internal (endogenous) developmental processes, children's performance on the experimental tasks is dialectically understood in terms of the meaningfulness (i.e. purposefulness of subjects' actions) that the experimental activity invokes within the larger system of their participation and engagement in the activities of their society and culture.

EXPERIMENTAL TASKS

RATIONALE

The "Circles Tasks"² were adapted from the neo-Piagetian study of pupils' development and acquisition of formal operational thought processes conducted by Pieraut-Le Bonniec (1980) with French children and subsequently replicated in South Africa by Macdonald (1987). These studies investigated the development of the notions of *possibility* and *necessity* in children and were premised on the Piagetian idea that operational children, around the age of ten, have some intuition of the "possible" states of affairs. That is, these children acquire the awareness and understanding of what is possible and what is necessary from a given situation once they have reached the formal operational stage of development which, in Western societies, is fully achieved around the age of ten to twelve years of age. However, this awareness first arises around the age of seven, as a concrete operational form of thinking where the understanding of possibility and necessity, for example, is tied up to the child's concrete experiences.

² The name 'Circles Tasks' is used in the present study to denote the experimental tasks, replicated from Macdonald (1987), involving subjects responding to questions about the possible shapes that could be made from the different task situations presented to them through the tinfoil covered and the uncovered half-circles.

On the other hand, the preoperational child, just before the age of seven (in Western societies), is more likely to explain situations on the basis of the characteristics of their configurations rather than on the basis of their transformations or changes leading from one situation to the other. Cognition at this stage is still bound up with concrete reality or what events and situations actually look like and is therefore not likely to manifest the understanding of the notions of possibility and necessity (Piaget, 1964; Pieraut-Le Bonniec, 1980).

The Circles Tasks in the present study derive from the general Piagetian framework. According to this framework, all children irrespective of their social and cultural situation go through the same stages of development that make learning possible. What differs, from one society and culture to the other with regard to development is the pace at which development takes place. This difference can be explained through social, cultural and—more specifically, educational factors. These factors impact directly on the child's maturational, experiential and self-regulatory processes. Children may, from this particular framework, develop and acquire formal operational conceptual abilities at an accelerated rate when the educational and cultural processes provide the appropriate stimulation, but to a limited degree. Children can as well develop and acquire these abilities at a slower pace, where the socio-cultural factors inhibit self-regulatory possibilities.

Consequently, social transmission and educational processes are often deemed to account for the systematic lag in children's developmental acquisition of operational thought processes. The possibilities for a differently elaborated developmental trajectory necessitated by the subject's culture and society have not been considered by studies on children's experimental tasks performance in South Africa. The current study therefore considers the possibility of applying the Vygotskian methodology to extend and complement on the potential for understanding the relationship between culture and cognition from the Piagetian framework.

According to Piaget, concrete operational thought (around 7-11 years of age) is characterized by the extension of actual or concrete reality, towards the direction of the potential, or the possible. It is at this stage that the child begins to think in terms of what is possible and proceeds by formulating hypotheses about possible states, instead of thinking exclusively in terms of his perceptions of concrete situations. Classification of objects, for example, would be viewed as requiring a set of class inclusions. New objects can be included in a system of relationships with the objects that have already been classified. Thus, further class inclusions become continually *possible* within a given system of classification. At about 11 years of age, children are viewed as having developed capacities for formal-operational thinking, technically referred to as the *hypothetico-deductive* reasoning. Hypothetico-deductive thought proceeds from what is possible to what is empirically real. The deduction refers to the hypothetical statements or propositional states rather than to perceptions of concrete situations. As a result, instead of deriving the

conclusion about what is possible directly from the empirical data and concrete states, the formal operational child at 11 or 12 years of age begins with the postulation that certain relations are necessary (Piaget, 1964; Pieraut-Le Bonniec, 1980).

Pieraut-Le Bonniec (1980) found that the ability (in her French sample) to maintain uncertainty in relation to undecidable situations, that is, situations that require them to think in terms of what is possible rather than in terms of what is empirically real, emerges at about ten years of age. By this age, Pieraut-Le Bonniec's children were able to differentiate with regard to experimental situations between instances where information for making a decision is lacking to cases where the information is complete to give judgement. That is, they were able to perceive and to distinguish between situations where something was "possibly the case" to where something was "necessarily the case". Macdonald (1980) also found the same with regard to her South African "multicultural" school pupils in her study. Conversely, pupils from the "township" schools in Macdonald's study manifested an apparent developmental lag in that they did not perform competently on the tasks.

The results of Macdonald's study with regard to the township pupils can be interpreted in two alternative ways. First, it could be supposed that the poor performance was due to the fact that the subjects have not as yet fully acquired the formal thought processes necessary for understanding the notions of "possibility" and "necessity". In this interpretation, the subjects' culture, that is, their schooling, language and life experiences would be viewed as inherently inadequate for stimulating the development of the formal operational thought processes. This interpretation is in doubt because the subjects are able to respond to some of the tasks questions and solve the related problems competently. The second alternative interpretation would be that the subjects have achieved the necessary stage of operational thinking, as evidenced by their competent performance on the majority of the tasks situations, but apply this form of thinking inconsistently in their tasks performance because of the influence of their culture and schooling. That is, the socio-cultural processes that mediate psychological development and functioning generate plural forms of developmental achievement, accounting for the heterogeneous processes in which the preoperational modes continue to coexist with the concrete operational modes and codetermine task performance of subjects who are nonetheless already at the concrete operational stage of development. This interpretation is grounded on and seeks to expand the 'not as yet elaborated' Piagetian view of cultural differences in learning and their consequence on psychological development and functioning. The specific cultural contexts, as Piaget (1966/1972) has acknowledged, would have an influence on development and may impact on task performance in important ways.

AIM AND HYPOTHESIS

The cultural difference hypothesis presupposes that different practices of society and schooling yield different cognitive performance. That is, the practices of culture and schooling that emphasise concrete and experiential modes of learning and knowledge acquisition are likely to produce the related modes of performance in pupils *pari passu* with the modes of cognitive performance that owe their development to the subject's spontaneous activity.

This therefore makes possible a pluralist assumption about knowledge development and functioning, where the spontaneous developmental processes such as those proposed in the classical Piagetian tradition, coexist ontogenetically with the cultural developmental processes such as those proposed in the Vygotskian tradition. The extension of the Piagetian interpretive framework on the basis of the Vygotskian socio-cultural framework in the current study aims to provide an important perspective on the role that culture plays in determining the course of development and learning.

RESEARCH DESIGN

The current experimental tasks made use of four circles of different colours, two red and the other two green. The circles are made out of a hard cardboard box. Two of these circles, one red and the other green, are each cut in the middle to make four half-circles so that there are two red halves and two green halves. The other two full circles, one red and the other green, are left uncut and are only used in the pre-test teaching or demonstration stage. The pre-test teaching and demonstration session was aimed at assessing the subjects' understanding of the concepts and the procedures to be used during the experiment. For example, a red circle would be shown to the subject to demonstrate the concept of "circle" and the colours "red" and "green."

The half-circles are used during this pre-testing stage to assess the subject's understanding of the different colour situations that can be made by placing two similar or two different- colour half-circles together into a full circle. For example, a subject is shown, by demonstration and explanation, that two same colour halves are placed together to make an all-red or an all-green full-circle. Alternatively, different colour-half-circles are placed together to make two full circles, each with two contrasting colours, a green-and-red colour full circle, or a red-and-green full circle.

During the pre-testing stage, the subject³ is also encouraged to play with the experimental materials. The interview is conducted in the subjects' home

³The technical term *subject* is used interchangeably, during this study, with child or pupil, but is commonly used to refer to the child (pupil) participating in the experimental study.

language. However, some of the subjects (especially the Grade Five and Grade Seven subjects) preferred to identify the objects and colour names in English.

SUBJECTS

A total number of eighty pupils were interviewed for these tasks. Twenty pupils were randomly selected from each of the four selected Grades in the junior primary and senior primary schools. Grade One and Grade Three subjects were selected from the junior primary school while Grade Five and Grade Seven subjects were selected from the senior primary school. Only two classes from each grade were randomly chosen to participate in the study. Subjects were selected randomly by selection of names from the class register. The researcher would identify a name in the class register, which he asked to keep during the experimental sessions and send for the child by that name to come for the interview. The child would then be asked if she or he would like to participate or if she would not want to take part in the "game"⁴. The formal experimental session would begin only after that the invited child has expressed an interest in participating in the "game", which was generally the case with all the children invited. The experimental sessions were conducted in a room that the schools made available for the purpose.

The average age of pupils in Grade One was six years old. Grade one was, for the majority of pupils, their first encounter with formal learning. Kindergarten or similar pre-school formal learning experiences were not accessible. By Grade Three, pupils are generally eight years old. The junior primary school had four grades, that is, Grade One to Grade Four. The senior primary school pupils who participated in the study were selected from Grade Five and Grade Seven classes. The average age for Grade Five pupils was ten years old while the average age for Grade Seven pupils was twelve years old.

The senior primary school pupils, especially the Grade Sevens, fell within the Piagetian formal operational stage and should theoretically be able to solve problems that required the understanding and awareness of "possible" and "necessary" states of knowledge. With regard to the junior primary school pupils, the Grade Three subjects are, from the Piagetian perspective, at the concrete operation stage and should therefore only be able to understand and use operational forms of thinking when this is tied up with concrete situations. That is, they would for example be able to say that something is "possibly the

⁴In the interviews with the pupils, the tasks were generally referred to as the "colour game". The notion of "game" was aimed at making the task less formal and less school-like to the subjects, so that any possible failure to provide an answer is not likely to be interpreted in a negative light.

case" or "necessarily the case" when they can actually observe the relation or transformation represented before them in concrete terms.

It should therefore be expected that the present task would be somewhat difficult for the Grade Three subjects, especially where the relations are not accessible to observation. The Grade One pupils, on the other hand, who fall outside the concrete operational stage, could theoretically not be expected to perform competently on the tasks. However, their responses to the tasks questions should provide important insights into the nature of concepts that prevail at this level of schooling and development and what influence their culture and schooling exert on their thinking and development. .

MATERIALS

As outlined in the research design section above, the experimental materials comprised half circles of two contrasting colours. There were two red half circles and two green half circles. The half circles can be placed together to form a one colour, red or green full circle or a one colour, red and green full circle. The other materials, red colour full circle and green colour full circle, were only used to illustrate the content and procedures of the experiment. The tinfoil was used to cover one half-circle on the basis of which the subject had to hypothesise about the colour values that could be made.

EXPERIMENTAL PROCEDURES

Demonstration: First, the researcher asks the subject, showing them the red and the green full circles, if they knew what these shapes are called and what their colours are. If the subject does not know the names of the shapes or the colours, which was rarely the case, the experimenter tells them and ensures that they use these consistently during the testing stage. The second part of the demonstration stage involved showing the subject how the half circles combine to form an all red or an all green full circles or a red and green full circle. The third part of the demonstration stage involved the researcher covering two half circles of contrasting colours with a tinfoil paper and asking the subject to take one half out of the "game". The researcher takes out one uncovered half out of the game so that a covered half and an uncovered half remains in the game. The subject is asked to think about the colour value of the covered half "as either green or red" so that he/she could be able to say what possible colour circles could be made. After that the subject has demonstrated an understanding of these procedures does the testing stage begins.

Testing: After the teaching-demonstration stage, the experimenter again asks the subject to choose any one of the four half circles in the game and place it aside. After the subject has picked one of the four halves, the experimenter

also picks up the other half circle of a different colour value to the one that the subject has just picked up. The experimenter takes the two halves, one that he picked up and the other that the subject has also picked up, and wraps them using a tinfoil paper. The experimenter makes sure that the subject does not see the colour value of either of the two halves as he covers them and that the subject continues to view the colour value of the two halves as either green or red, after they have been covered. This procedure leads to what became the first situation, *situation 1*, of the experiment.

Situation One involved the experimenter asking the following questions in their order. The numbers in brackets represents the specific order in which the questions were presented:

- (1a). If we remove the foil, will it be possible to make an all-red circle?
- (1b). If we remove the foil, will it be possible to make an all-green circle?
- (1b). If we remove the foil, will it be possible to make a one-colour circle?
- (1c). If we remove the foil, can the full-circle be red-and-green in colour?
- (1d). If we remove the foil, will the circle be of one or two colours?
- (1e). If the circle that is made out of these two halves is one colour only, what colour does it have to be?
- (1f). A few minutes ago, another child made a one-coloured circle using the same halves as these in front of you. What colour do you think it was?
- (1g). What colour can all the circles that can be made out of these halves be?

A question is either repeated or re-phrased where necessary, both at the request of the subject or at the discretion of the experimenter, as a way of facilitating the subject's understanding and active participation.

When situation 1 has been addressed, the subject is presented with situation 2 questions. Situation 2 involves the experimenter placing into the game an additional, uncovered, half circle of a contrasting colour to the red half circle. That is, a green uncovered half circle is placed into the game so that situation 2 comprises three half circles: a red uncovered half, a green uncovered half and a tinfoil-covered half. The following questions are asked in the order represented below:

- (2a). Can we make a red-and-green colour circle?
- (2b). Is there another way in which a red-and-green circle can be made from the half circles in front of you?
- (2c). With these half circles, will it be possible to make an all-red circle?
- (2d). If the tinfoil is removed, will it be possible to make an all-green circle?

- (2e). If the foil is removed, can we make a one-coloured circle from these halves in front of you?
- (2f). If we want to make a one-colour circle, by these halves in front of you, what colour will it be?
- (2g). If the foil is removed, what are the different-colour circles that can be made from the half circles in front of you?
- (2h). If the one colour circle that is made from these halves in front of you has to be one colour only, that is, all-red or all-green, it has to take the colour of one of these three halves. Can you say which one this half circle is and why do you think so?

RECORDING OF DATA

Data in the form of the subjects' responses to the tasks questions were tape-recorded. The summary of the interview, in the form of the interview questions and the subjects' response patterns, was recorded in a notebook at the same time that the interview was taking place. For example, a response that reveals the subject's understanding of the notions of possibility and necessity is recorded as a "competent" response while the response that manifests a lack of such understanding is recorded as "not competent" or "incompetent". The subject's response is recorded as incompetent when it ascribes a colour value to the covered element. Conversely, the response is recorded as competent when it proceeds from an "either-or" situation and demonstrates an awareness of the hypothetical state of knowledge with regard to the colour value of the covered element.

METHOD OF ANALYSIS

The data were analysed through the examination of the patterns of the subjects' responses. That is, in terms of whether the subjects' responses were competent or incompetent with regard to the understanding of the notions of possibility and necessity. That is, a response that suggests that the subject does not ascribe a particular colour value to the covered element—formulates a hypothesis about the covered element, and arrives at an indeterminate decision about the colour situations is considered competent. On the contrary, a response that suggests that the subject ascribes a definite colour value to the covered element and thinks about the covered element in concrete terms; that is, in terms of "what is" rather than in terms of "what might be", is considered to be an incompetent response.

RESULTS

The Grade One subjects experienced the most difficulties in responding competently to the tasks questions. These subjects obtained the overall competent response of only thirty six percent. The Grade One subjects performed worst on five task situations; namely, *situation 1c*, *situation 1f*, *situation 2f*, *situation 2g*, and *situation 2h*. In these task situations, jointly considered, the Grade One subjects were only able to provide two competent responses.

The Grade Three subjects obtained a 64% competent responses. There is therefore an emergent mastery of the tasks that is manifested by these results. The Grade Five subjects obtained 68.9% while the Grade Seven subjects obtained 84.6% (see the summary representation below in tables 1 and 2).

Table 1.: Overall total numbers of competent responses to both *situation 1* and *situation 2* questions by subjects from across the four Grades

Grades	Grade 1	Grade 3	Grade 5	Grade 7
Responses in % out of a total of 280 responses per Grade.	36%	64%	68.9%	84.6%

Table: 2.: Subjects' average performance on the Circles Tasks.

Level of grade	N	Tot_T1	
		Mean	Std Dev
1	20	2.40	1.54
3	20	3.95	2.24
5	20	5.00	1.86
7	20	6.00	1.21

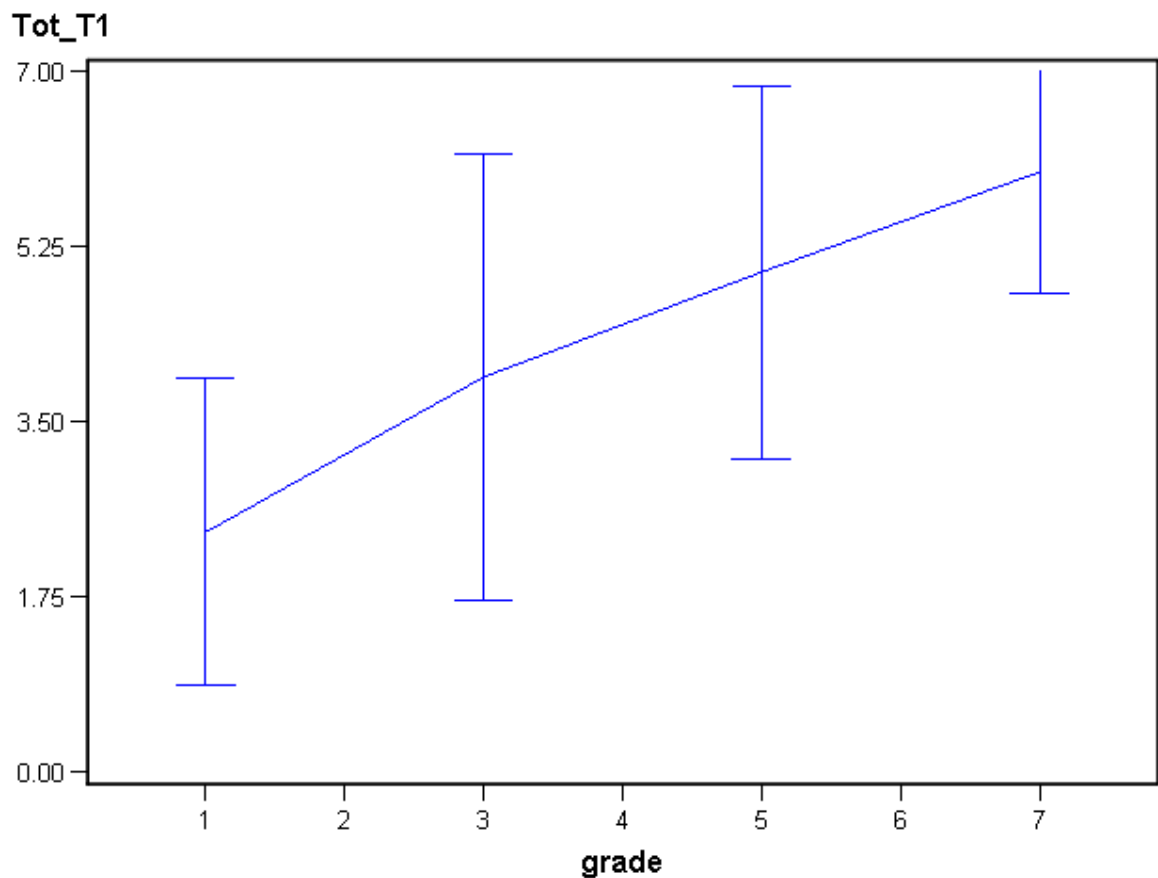


Figure 1.: Average task performance levels per grade on the Circles Tasks.

DISCUSSION OF RESULTS

The performance pattern across the four Grades is consistent with Piaget's theoretical proposition that propositional forms of thinking emerge at the concrete operational stage around the age of seven years old. This is progressively consolidated with the achievement of the formal operational thought—around the age of ten to twelve years of age. However, because the emergence of the stages is not strictly tied up to the specific age levels, the manifestation of the general capabilities that characterise a particular stage may occur at a slightly earlier or later years, depending on the social circumstances of the child (Piaget, 1964). The results in the current study support this general theoretical proposition.

A one-way *Anova* procedure was conducted to determine if the change in performance across the grades was significant. The results of this procedure (see table 2 and figure 1 above) confirm significant differences between the performance levels of the Grade One subjects and the Grade Three subjects and between the Grade Three subjects and the Grade Seven subjects, respectively. The *post hoc* test of the *Anova* procedure (see table 2 above) indicates where the significant differences across the grades are located. This data confirm the theoretical proposition about the major stage-like transitions from the lower level to qualitatively higher-level forms of thinking in children. In the present experiment, the effects of the experience of schooling and the quality of learning and concept development on the subjects' performance cannot be ignored.

Contrary to the performance of their counterparts in Pieraut-Le Bonniec's (1980) French subjects and Macdonald's (1987) Scottish and South African multicultural church school subjects in the studies discussed above, only 69% of the responses of the ten-year-old Grade Five subjects in the current study responded competently to the task questions. Meanwhile, the twelve-year-old Grade Seven subjects offered the overall competent responses of 85%. Whereas the overall performance confirms the theoretical proposition about developmental progression of thinking and the approximate chronological age of their emergence, the results reveal a comparatively lower percentage scores. As a result, the performance levels of the subjects in the present study falls behind those of their more 'westernized' counterparts in the other studies described above.

These performance differences are likely to be more adequately explained if we consider the subjects' task performance not as only involving internally driven externally oriented actions. That is, task oriented actions of the subject does not only reveal the internal structure of the individual's actions but also the perceived structure of the task in which the subject is participating. The subject's perception of the task demands is crucial for the subject's organization of their performance actions. The structure applied to the resolution of the task problem is therefore not only located in the subjects' mind—conceived as an internal possession of the individual. The perceived structure of the problem to be solved may lie somewhere between the individual and his or her social relations, in the repertoire of the individual's social activity system. In other words, the social processes of learning, such as that involved in formal schooling, may influence the individual's problem solving approach and the associated problem solving strategies. As a result, developmental acquisition of functions and processes may be multifaceted and dynamic at the same time that it manifests the basic structural organisation such as that proposed in Piaget's formulation. This, I believe, was Vygotsky's basic theoretical assumption which today is being expanded by many sociocultural theorists. As Stetsenko states:

[...] many sociocultural theories are based on the notion that social and psychological phenomena are processes that exist in the realm of relations and interactions—that is, as embedded, situated, distributed,

and co-constructed within contexts while also being intrinsically interwoven into these contexts (Stetsenko, 2008:in print).

In relation to the performance of the subjects in the present study, the experimental situation itself needs to be viewed as a social activity. The subject (or individual) participates in an activity determined by adults and produces actions that are the results both of his development and his learning. This development and learning can be viewed as the possession both of the individual and his or her society, as distributed between the two, and not as a possession of one in exclusion of the other. According to the sociocultural framework, none of the two processes, learning and development, determine the other in a neatly linear fashion. This is in contrast to the common polarised interpretation of the two framework's respective positions on the relationship between learning and development. Therefore, the subjects' task performance could not be interpreted as an exclusive product of their spontaneous development. The two should be viewed as co-determining each other and as dialectically related. While acknowledging the spontaneous developmental process, located in the activity of the subject, the social relations of the subject to processes that are essentially social and cultural should provide a complete picture of development. Such a picture does not emphasize an isolated subject at the expense of his or her social relations and vice versa. The concept of development, from the present analysis, is therefore expanded to include both the Piagetian and the Vygotskian interpretive frameworks for an all rounded understanding of the subjects' task performance.

The explanation for the subjects' task performance should be sought beyond the deficiency notions of culture and cognition. The modes of classroom teaching and learning and the practices of the subjects' culture and society should be considered as factors that influence development and task performance. That is, subjects' responses to the task questions and their actions to solve the tasks problems are viewed as essentially influenced by the practices of their culture and society as much as they are determined by the subject's task-oriented activity. Subjects may, for example, adopt a particular orientation to understanding and resolving problems that derive from the practices of their schooling and society. That is, they may adopt an orientation that that derives from their specific modes of learning in school or learning in their everyday situations, their language practices and concepts embedded in these practices. They may, for example offer responses that derive from a premise that contradicts the one assumed by the experimenter without the experimenter realising it. That is, they may interpret a phrase in the task question: "If we remove the foil...", from the point of view of their language practices and their learning experience as suggesting a concrete action of uncovering the task element concerned. As a consequent, the responses they provide may proceed from the assumption that the task question suggests a concrete activity, something like a cultural riddle that needs to be solved by suggesting a definite solution that with a concrete application.

This view differs from that which assumes that responses to tasks questions, and the actions to resolve the tasks problems, emanate exclusively from the child's own internal cognitive activity. The present view conceives of the child's activity as inextricably intertwined with its specific cultural and societal setting. That is, what specific culturally derived conceptual tools does the child use to orient him to the task problem and to act to resolve it in the manner that makes cultural sense to him. For example, a child may understand situation 1f question: "A few minutes ago, another child made a one-coloured circle using the same halves as these in front of you. What colour do you think it was?" in a concrete sense because he does not often or consciously encounter situations in his language, or in his school learning, where hypothetical situations are presented for the sole purpose of resolving the proposition. This is different from saying that the child has no conceptual ability to understand hypothetical situations. Rather, the use of the hypothetical person does not make reasonable 'cultural' sense to the child because his schooling and his culture do not deliberately engage him in such mode of questioning. The mode of questioning that is emphasised in the child's learning may be dominated by questions that relate to concrete situations and real life experiences. These modes of sociocultural practice, as discussed below, can be related to subjects' school learning and everyday, spontaneous activities.

Grade One

The Grade One subjects showed no understanding of the experimental tasks as a whole. They did not make sense of the task procedures and they did not focus on the task questions in their responses. Their responses to the task questions were generally incompetent. Their overall performance score of 36% indicates a lack of consistency in their responses to the task questions. Although the Grade One subjects occasionally demonstrated an apparent sense of understanding of the possible, this understanding was tied up to the concrete appearance of the concrete objects in the task. For example, in response to task situation question 1a, subjects would say that it is possible to make an all red circle but not perceive this possible state in hypothetical terms. That is, the subjects' notion of the possible was related to the notion of the actual, where a situation is perceived as possible because it is simultaneously perceived to be actual or 'possibly-real'. That is, something is possible because it is 'do-able'. The perception of possibility is actually subordinated to the overarching structure of the concrete and the real.

Grade Three and Grade Five

The Grade Three and Grade Five subjects, while showing very little differences between themselves, demonstrate greater competence when applying the concepts of possibility and necessity in addressing the task problems. The performance score of the Grade Three subjects was 64% while

the Grade Five subjects obtained a 69% competent responses on the tasks questions. These subjects could clearly address the task questions competently, demonstrating an understanding of 'possibility' and 'necessity' situations. They can therefore not be thought of as not having acquired the necessary forms of operational thought structures that make such understanding possible. These subjects' understanding of the notions of possibility and necessity was tied up to the concrete tasks situations, confirming the theoretical point on the concrete nature of their operational thought processes.

However, the Grade Three and Grade Five subjects did not, as indicated above, obtain as high an overall score on the task questions. The Grade Five subjects, in particular, performed poorer than their counterparts in the comparative studies discussed earlier in this paper. The inability to perform competently on some tasks questions may be explained by reference to the experimental activity and the subjects' assumptions about the experimental tasks. This is where the subjects' culture and everyday activity *vis a vis* their formal school learning is examined. Culture and schooling provide conducive setting for the developmental acquisition and functioning of the operational thought processes. Conversely, the practices of culture and schooling may inhibit the manifestation of operational thought processes or their functioning. This however does not necessarily mean that the subjects have not yet acquired the operational thought processes.

Although in most of the task situations the subjects demonstrated that they had mastered the understanding and use of the notions of possibility and necessity, there were instances where the subjects went beyond the framework of the experimental tasks' demands. For example, forty percent of the Grade Three subjects argued, with regard to situation 1b question, that it is possible to make a circle that is green in colour. Twenty five percent of the Grade Five subjects also responded to this question in a similar fashion. This situation was in fact not possible to obtain from the given task situation because the uncovered half was already red in colour. In justifying their responses, most of these subjects argued that the green uncovered half outside the game could be joined with the covered half to make a green circle if the covered half turns out to be green. In this way, these subjects applied concrete thought processes, interpreting the possible in terms of the actual by importing outside information to enable a creation of a concrete situation.

The subjects used their global understanding of what different colour circles could be made, as demonstrated to them during the pre-test demonstration stage, and perceived the situation in terms of the "possibly-real". A similar mode of thinking was manifested in the subjects' responses to situation 1f question. Subjects would respond to question 1f: "A few minute ago, another child made a one-coloured circle using the same halves as these in front of

you. What colour do you think it was?" in concrete terms. They responded that they did not know what the other child did because they did not see the other child performing the task. Apart from these specific patterns, in many of the task situations where they failed to perform competently, the subjects ascribed a definite colour value to the covered element and responded to the task questions from the perspective of what the situation "is", instead of what "it could possibly be".

Grade Seven

The Grade Seven subjects responded competently on 85% of the task situations. This demonstrates that these subjects understand the notions of possibility and necessity in the experimental tasks. However, the subjects were also susceptible to responding incompetently on specific task situations. For example, the Grade Seven subjects, like the majority of the subjects in the other grades, tended not to respond competently to situation 1f and 1g.

Situation 1f proved to be the most difficult for the subjects. This is because the hypothetical statement: "A few minutes ago another child made a one-coloured circle using the same halves as this in front of you...", was often interpreted in concrete terms, where its meaning was given a literal interpretation. The notion of "another child" tended to be interpreted as referring to a real person who had earlier on participated in a similar experiment. As a result, most subjects argued that: "It depends on what colour halves the other child has used", or "I cannot say what colour it was because I did not see what the other child did". These subjects interpreted the hypothetical child in the task question in a literal sense as referring to a real event that happened earlier on and sometimes thought of the participants who have gone before them as the possible child the statement refers to.

In the case of situation 1g, as in questions 2g and 2h, that required the formulation of a double hypothesis about the covered element, most subjects performed incompetently. This may be due to the subjects' tendency to think of the possible as also involving the real, thus assuming that the alternative state becomes impossible once first or second state has been proposed. For example, for situation 2g question: "If the foil is removed, what are the different-colour circles that can be made from the half circles in front of you?" the subjects found it difficult to include all the three possible states, namely: all red, all green and red-and-green full circles. Again, situation (2h) question: "If the one colour circle that is made from these halves in front of you has to be one colour only, that is, all-red or all-green, it has to take the colour of one of these three halves. Can you say which one this half circle is and why do you think so?" the subjects failed to identify the relevant half circle as the covered half and therefore also failed on the other aspects of the question. Where the subjects successfully identified the relevant half as the covered half, they failed to provide the relevant reasons, which should involve identifying the two possible colour circles that could be made depending on

what the covered half turns out to be. These two situations proved most difficult for the subjects in spite of the fact that they have theoretically acquired the formal operation thought processes already. This fact should demonstrate the point that the relational and contextual aspect of psychological development and functioning is equally important for understanding the complex nature of the developmental acquisition and functioning of operational forms of thinking within real, psychological subjects.

CONCLUSION

Research on children's learning and the development and functioning of thought processes during schooling is important, especially in the present period of rapid changes within the South African schooling system. The present study examined the developmental acquisition and functioning of operational thought processes in primary school learners in South Africa, and in Venda in particular. The study, following Pieraut-Le Bonniec's (1990) and Macdonald's (1987) studies respectively, examined the modes of performance of primary school learners on the experimental tasks.

The results for the experimental tasks support the theoretical idea that children acquire operational forms of thinking around the age of ten years old (Piaget, 1964; 1968; 1970); 1981). However, children growing up and learning in non-industrialized sociocultural settings such as those in the present study manifest the development and functioning of operational thought processes differently. That is, their performance on the experimental tasks reveals a degree of inconsistency in their application of operational forms of thinking to the task problems. The present study posits that this phenomenon not be interpreted as suggesting a cognitive lag in the subjects' development, or a deficiency in their culture accounting for the subjects' inability to perform competently of the tasks. Rather, the subjects' task performance should be interpreted as manifestation of the subjects' developmental process within the sociocultural setting of its manifestation. That is, development needs not be viewed only as the exclusive possession of the subject in isolation of the sociocultural processes in which and through which such development takes place. This later point is elaborated in the paper using the theoretical insights that the Vygotskian framework provides.

This paper therefore contributes new ways of thinking about the learning and development of children in non-industrialized sociocultural settings. The paper proposes that task performance of children in these situations may reveal patterns of thinking that derive from the structure of knowledge practices and relations in society, what Vygotsky (1989; 1981) referred to as 'interpsychological processes', at the same time that they manifest evidence of the underlying structural capacities that characterise the operational stage of development. This interpretation allows us to explain the task performance of children in non-industrialized sociocultural settings on the experimental

tasks of the Piagetian type and enables us to overcome suggestions of cognitive lag as well as the associated deficit assumptions.

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