Exploring Ghanaian Children Conservation of Number

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Abstract

The study was based on Piaget's theory of Cognitive development and the main aim of the study was to find out if Piaget's theory on children's number conservation at the concrete stage holds for Ghanaian early children. Fifty-four (54) kindergarten and lower primary school children were randomly selected from three (3) public and two (3) private schools purposively selected from schools in the Winneba Municipality. The procedure used was mainly interview method using some of Piaget's tasks to test for conservation of number. The 7-8 years old were identified to be conservers of number than the 3-6 years old. Generally, the results supported Piaget's theory of cognitive development where the older children (7-8 years) performed better than the younger children (3-4 years; 5-6 years) at the number tasks. There was also no significant difference on how the public and private school children performed on the number task. In conclusion, the results of this study agree with Piaget's theory of Cognitive development that the concrete operational stage marks the development of conservation and that the Ghanaian children tested were no different in their cognitive stage as with the Swiss children used by Piaget.

1. Introduction

The development of conservation of number is an important cognitive milestone in a child's development. Piaget's developmental theory led to substantial questions about conservation and related research about the development of conservation of number. Conservation of number is a mathematical concept that was first identified by Jean Piaget in the mid twentieth century. It is the recognition by a young child that quantity does not change with physical rearrangement. This key principle boils down to the insight that a numerical quantity will remain the same despite adjustment of its apparent shape or size. For instance if one is presented with a row of coins that is subsequently stretched out, it is obvious that adults and older children will have little trouble grasping that although the row will be longer when stretched out, the stretching does not alter the number of coins. Since the seminal work of [21] it is well established in the developmental literature that young children (until age seven) typically fail this task and seem to be convinced that the longer row also contains more coins [2; 8; 26]. Piaget's work on children's quantitative development has provided mathematics educators with crucial insights into how children learn mathematical concepts and ideas. This has helped to create a view where the focus of attention is on the idea of developmentally appropriate education.

2. Cognitive Development Theory of Piaget

Piaget was the first psychologist to make a systematic study of cognitive development and his work has gathered much attention within the field of education [18]. His study included a theory of child cognitive development, detailed observational studies of cognition in children, and a series of simple but ingenious tests to reveal different cognitive abilities. Cognitive development involves changes in cognitive process and abilities. The Swiss biologist and psychologist, Jean Piaget (1896-1980) observed his own children and their process of making sense of the world around them and eventually developed a four-stage model of how the mind processes new information encountered. He indicated a child's cognitive development is about a child constructing a mental model of the world and the development is biologically based and changes as the child matures. His four stages of development correspond with the age of the children and are as follows;

- The sensorimotor stage, from birth to age 2
- The preoperational stage, from age 2 to about age 7
- The concrete operational stage, from age 7 to 11
- The formal operational stage, which begins in adolescence and spans into adulthood.

Piaget made us understand each child goes through the stages in the same order, and no stage could be missed out - although some individuals may never attain the later stages and there are individual differences in the rate at which children progress through the stages. However, Piaget did not claim that a particular stage was reached at a certain age - although descriptions of the stages often include an indication of the age at which the average child would reach each stage. Instead, he suggested that there is a qualitative change in how children think as they gradually progress through these four stages. For instance, he indicated that a child at age 7 does not just have more information about the world than

he did at age 2; there is therefore a fundamental change in how he thinks about the world.

At the Sensory motor stage, Piaget suggested that the infant builds an understanding of himself or herself and reality and how things work through interactions with the environment. The child is able to differentiate between itself and other objects. Learning therefore takes place via assimilation and accommodation.

During the Preoperational stage, kids learn through pretend play but still struggle with logic. Piaget indicated that their intelligence is egocentric and intuitive, not logical. They also often struggle with understanding the ideal of constancy and are able to think about things symbolically, this is the ability to make one thing - a word or an object - stand for something other than itself.

The Concrete operational stage is the period where children demonstrate logical, concrete reasoning. Piaget considered the concrete stage a major turning point in the child's cognitive development, because it marks the beginning of logical or operational thought. This means the child can work things out internally in their head (rather than physically try things out in the real world). Their thinking becomes less egocentric and they are increasingly aware of external events. They begin to realize that one's own thoughts and feelings are unique and may not be shared by others or may not even be part of reality. As physical experience accumulates, accommodation is increased. The child begins to think abstractly and conceptualize, creating logical structures that explain his or her physical experiences.

In Ghana, formal education starts from Kindergarten at an average age of four years (4). Children spend two years at the Kindergarten and proceed to Basic One (1) by age Six years (6). Like in other countries, early childhood begins at age 0 and ends age 8 and this category of children are identified mostly in Piaget's Sensori motor, pre operational and early part of the concrete operational stage. Children below the ages of four are mostly found at the crèches and nursery centers (0-3).

2.1. Empirical studies on Conservation

Cognitive research shows that young children develop an extensive everyday mathematics and are capable of learning more and deeper mathematics than usually assumed. In Piaget's study, the concrete operational stage marks the development of conservation. He noted that children are able to conserve at the Concrete operational stage. Piaget (1941/1965) investigated the ages at which children discovered the conservation of mass, weight and volume and he observed that discoveries of conservation followed a regular order that was related to age. The study revealed that children could conserve number by age six (6), mass by age 7, and weight by age 9. However, many children during Piaget's preoperational stage are not cognitively developed enough to succeed at conservation tasks. Piaget concluded that children fail at conservation tasks because their thinking are not governed by principles of reversibility, compensation and identity just yet.

Many previous studies have tested the extent to which children of different ages can conserve. Relatively all evidence gathered from these studies suggest that young children cannot conserve on standard tests [2; 26; 30]. Young children, most educators, say are not capable of reason, and do not make the shift to rationality until they are between 5 and 7 years old [29]. Piaget's landmark studies indicated that children do not grasp logic until they are approximately seven years old [12]. This classic "theory of mind" experiments suggest that young children are poor psychologists. They act as if they do not understand the perspectives of other people [35; 20].

[14] in his study identified four levels of conservation. In the first level, the child is unable to make an equivalent set. At the second level, the child can create an equivalent set, but is unable to maintain the equality in the face of a perceptual change. At the third level, the child is unsure of equality or cannot provide a reason. At the fourth level, the child recognizes that the quantity does not change and can provide arguments to substantiate his reasoning.

However, in recent decades, researchers have re-examined old assumptions and found reason for doubt. This can be seen from literature that children's conservation errors have been studied extensively due to the fact that number conservation is important for a child's numerical and mathematical development [34]. They indicated that in the work of Piaget [22] who introduced the coin-spreading task, number conservation marked a critical transition from a preoperational to operational stage in children's thinking. According to Piaget, they stated, the non-conserving preoperational child cannot grasp the conservation principle because they are limited to a purely intuitive and perceptual way of processing information. That is, in the coin-spreading task the preoperational child will base his/her judgment purely on the visuospatial property of length. Consequently, they are bound to be misled by a length-equals-number intuition. Children, they say, may be confused by the experimental procedures. They may be puzzled by the unnatural wording of the test questions, or distracted by too many details [4]. [4], for example, used two presentations with equal numbers in the arrays that differed only in the nature of the materials and found a much greater percentage conserving when the children were asked

if there were the same number in the two arrays than when they were asked which array has more.

Several aspects of the conservation tasks have been criticized also, for example, that they fail to take account of the social context of the child's understanding. [29] questioned Piaget's line of questioning and argued that when a child gives the wrong answer to a question, the question is repeated in order to hint that their first answer was wrong. This, they indicated was what Piaget did by asking children the same question twice in the conservation experiments, before and after the transformation. They considered two specific linking hypotheses in their classic study, which investigated the effects of certain types of question on children and the responses children produced. The central phenomenon of the Rose and Blank study was the manner of questioning the children in typical conservation tasks and the child's subsequent response. [29] second hypothesis implicitly states that children would have an easier time successfully completing the one judgment task because there would be no pressure for the subject to gauge the researchers intentions or intended response from the subject. It is this style of questioning that this study used in testing the samples involved.

[17] pointed out another feature of the conservation task which may interfere with children's under-standing in which the adult purposely alters the appearance of something, so the child thinks this alteration is important. They therefore devised a study of conservation of number in which the alteration was accidental. They laid out two identical rows of sweets and the child was satisfied there were the same number in each; a 'naughty teddy' appeared. Whilst playing around, teddy actually messed up one row of sweets. When he was safely put back in a box, the children were asked if there were the same number of sweets. More than half of the children who were between four- and six-years-old gave the correct answer. This made them to suggest that Piaget's design prevented the children from showing that they can conserve at a younger age than he claimed.

[36] conducted a similar study by investigating the occurrence that young children can in fact; conserve number when tested with small quantities. The small quantity contained approximately 3-4 chips while the large quantity contained 5-6 chips. Winer's findings suggest that the child's understanding of small quantities might possibly play a role in the development of conservation of larger numbers. The central phenomenon Winer's study explores is whether children will have a higher ability to conserve number in an experiment when tested with small quantities rather than large quantities. His linking hypothesis stated that younger children are tested with small quantities will have a higher ability to conserve number than those who are tested with large quantity sets. Alternately, despite the evidence of conservation found, it may be that young children cannot perform or be tested on ability to conserve.

[1] conducted a similar study to Winer's to test ability to conserve using small and large quantities to a 3 and 5-year-old male and female children attending preschool. Each child was assigned to a specific condition and she utilized two different conditions, which dealt with the order of varying chip quantities. As part of her findings, her study did not fit with Winer's linking hypothesis because Winer suggests that young children will be more successful in number conservation when given small numbers. This was not the case in her study, as only one child was able to conserve number even children given a small quantity of chips were not able to conserve. She found that the quantity order in which the child was assigned to did not make a difference in whether or not the child was able to conserve and suggested that children ages 3 and 5 do not have the ability to conserve number in any manner.

3. Statement of the problem

In Ghana, preprimary education is a prerequisite to primary school education and this has increased the number of kindergarten/preschool and private schools especially in the big towns. It is therefore important that curriculum developers/teachers understand the processes of cognitive development as well as knowing which level the child would be ready for certain concepts to be taught.

Piaget's study, as seen from literature is considered relevant to children's cognitive development and the way they learn. Around the world, people hold similar views about the timing of cognitive development. Many studies have been done cross-culturally on Piagetian theory with concentration on primary and post primary levels as literature review had shown. However, in Africa, not much has been done on pre-primary school level as far as conceptual development is concerned. Research in cognitive development among preprimary school children has been done in other societies such as by [16; 32; 4; 5; 37; 19] and it is these researches that this study replicated on some Ghanaian early children to find out if his findings on Swiss children hold cross-culturally.

4. Purpose of the Study

Consequently, the present study attempt to explore what Piaget did with his Swiss children at the early childhood school level, concentrating on number conservation. This study was moreover concerned with the importance of including justifications of responses in assessing conservation status using the revised question format. It was also

to study the effect on conserving status of different types and numbers of transformations among the children of age range in the preschool to lower primary. This is simply to confirm Piaget's Cognitive stages and the Ghanaian child's ability to conserve number. The results of this study would increase our knowledge on cognitive development at preprimary and primary school level, which is important for curriculum planning, and development in this area.

5. Hypotheses

The following hypotheses were set for the study.

1. The 3 and 4-year old will have a higher ability to conserve number with smaller quantities rather than with larger quantities.
2. The 5 and 6-year-old would not have difficulty passing the Piagetian task on number conservation
3. The 7 and 8-year-old children would have an easier time successfully completing the one judgment task on conservation on number.
4. There would be no significant difference between the Private and Public school children in their conservation of number.

6. Method

The population was a convenience sample consisting a final population from six schools in the Efutu Awutu Municipal Assembly of fifty-four children. The children used for the study were Nursery/Kindergarten and lower primary children from three public and three private schools in the Municipality. The Nursery/kindergarten children ranged in age from three years to five and a half years (3-5½) and the primary school children ranged in age from six years to eight years. Three children from each age range category were purposively selected for the study making nine (9) children from each school. This was to help the researcher have a cross section of the children or each age group from the schools involved in the study in order not to make judgement from only one school.

The study adapted Piaget's standard Piagetian task on number conservation using the one judgement task [29]. In the one judgment task the children watched the experimenter manipulate the objects and were subsequently asked if the two rows were equal. The one judgement task was used considering the criticism assigned to Piaget's Standard conservation test where objects were lined up in a 1:1 ratio, the children were asked if the rows were equal then one row was expanded or contracted and then children were asked again whether or not the rows were equal. The study used interview as a clinical method of testing the children on the Piagetian task. The children were tested individually away from the other children. The mode of instruction was both English and Fante depending on what the child feels comfortable communicating in. The fante was used more in the public schools because the L1 (local language) is most often used in the lower primary and preprimary.

6.1. Procedure and Materials used

Considering other studies and criticism on Piaget's line of questioning, the researcher categorized the children's activities as follows;

- The 3-4-year olds were tested using smaller quantities (3 objects) to see if they could conserve number.
- The 5-6-year olds were tested on conservation of number using 5 objects and increased the number of objects to seven.
- The 7-8 year olds were tested using the one judgmental task whilst increasing the number of objects used to a maximum of 12.

The materials used in the study were varied and included miniature toys of different colours, colourful countables (painted shells, bottle tops and cubes), plastic little cups and spoons. This is because previous studies (Hood, 1962; Piaget, 1952) have found that provoked correspondence using complementary materials (example, eggs and egg cups, flowers and vases) tends to facilitate conservation of number to a greater extent than unprovoked correspondence which uses homogeneous materials (e.g., all shells).

6.2. Activity

The children's ages were the criteria used in the selection; any child who fell in the standard age in each class from KG 1 to Basic 3 (elementary 3) was considered and three (3) from each class were purposefully selected by random selection for the study. Before testing them each child was briefed on the activity that was being carried out which relaxed him/her and was given candies for participating in the study after the test. Each child was given three (3) tests using different materials (objects) and varying the position of the materials in each stage. A follow up question to confirm their responses was asked in each case. For instance, "how can you tell?", "Why do you say they are the same in number?" The tests were structured in three stages;

1. Using same objects and colours
2. Using objects with different colours with same quantity
3. Using matching objects of different colours

6.3. Procedure

In testing the three and four-year (3-4) olds, the experimenter used two sets of three (3) same colour and different colour miniature toys as well as mini cups and spoons (Winer, 1974). The objects were placed in a row with one side facing the child and the other side facing the researcher. The one judgmental questioning was used for each child as a result one of the sets was spread to enable the child answer the conservational task. The child was asked if the row in front of them had same number of objects as those in front of the researcher. Below is a sample of the interaction between the researcher and a child;

Researcher: I want you to look at the toys in front of you and the one in front of me; do your toys have the same number as mine?
Child A: ……
Researcher: Why do you say "no" or "Yes"? (depending on the response).

The five and six year olds were tested using 5 coloured shells, miniature toys and cubes. Same objects of different colours as well as different objects were placed in a row in front of the child and the researcher (spread) in the process of questioning. The child was to tell whether the rows in front of them are same in number. The position of the spread objects was changed after each questioning. Two additional objects were added to a row and child was to tell whether the number of shells were the same or not.

The 7-8 years had ten different matching colours of bottle tops, miniature toys, cubes and shells. This was also to test the children's matching skills. They were to determine if the rows are the same or not. The one judgmental approach was used in this case. The row in front of the child was spaced out (spread) and the child was to determine if the two rows were same or not. The number of objects in a row was increased from 10 to 12 to test whether the child could still identify the change.

7. Results and Discussion

Although children were equally likely to judge either way on any one display, it was reasoned that if they understood conservation they would show consistency in their judgements of the transformation. Without understanding of conservation, successive judgments would be independent of each other.

The results of the 3-4-year olds conservation task revealed that none of the 3-4 year olds could tell that the two rows have the same quantity in each case of questioning. It was found that 3-4-year-olds' judgments were independent, showing no recognition of invariance at all. Some of them just pointed to the one in front of them and said that was more. Even when one row was expanded some still maintained what was not expanded still had more toys. Some were seen counting by touching the toys one after the other but could still not tell which row had more. Some of them just moved the toys in some meaningless way- including just rearranging those in the row, or meaninglessly shifting them. As a result, the null hypothesis was rejected that the 3-4-year olds would have the ability to conserve with smaller quantities and the alternate hypothesis accepted that 3-4 year olds would not have the ability to conserve on smaller quantities. This was in spite of the small quantities of the objects used the children could still not conserve. The finding therefore corroborate example, [2; 26; 30] evidence gathered from their studies that suggest young children cannot conserve on standard tests.

The 5-6-year-old test resulted in most of the 5 year olds having difficulty identifying whether the rows were still the same when additional objects were added. It was observed that almost all of them were able to count and gauge number, as they provided the correct answer to the investigative query. Nevertheless, when a shell was either added or subtracted, fewer than half of the 5-6 year olds correctly answered both of the "conservation" questions, the same children were not able to conserve. When asked to tell whether the altered rows have same number of objects, some of them responded that the spread row had more objects than the other row "this row is bigger because those chips are bigger". Some of them focused on the chips as individual objects and not as a long row. When asked if the two rows had the same number of objects, some responded with an answer specific to the specific object and not the overall row of objects. However, it was observed that some of the 6 year olds were counting the objects in each row to support their claim that the two rows were either same or not. The Alternate hypothesis (Ha) was therefore accepted that the 5-6-year olds would have difficulty passing the Piagetian task whilst rejecting the null hypothesis that the 5-6 year olds would have no difficulty passing the Piagetian task. This is because a greater number had difficulty identifying whether the rows were still same when additional shells were added.

The findings from the 3-4 and 5-6-year olds confirm Piaget's assertion that children in Piaget's preoperational stage are not cognitively developed enough to succeed at conservation tasks. Piaget concluded that children fail at conservation tasks because their thinking were not governed by principles of reversibility, compensation and identity just yet. The non-conserving child does not find the second presentation equivalent. According to Piaget, a preoperational child does not remember the prior

states and focuses overwhelmingly on perceptual attributes in their decision-making process.

The 7-8-year olds judgments were significantly more consistent than would be expected by chance. They were observed to be conservers since all of them could tell there was no difference in the number of objects in both rows in spite of their arrangement. Some of them matched the objects in the two rows to support their claim of same number of objects. Some were seen counting the objects in each row and used that to confirm their answers. When additional object was added to or subtracted from the rows, it was noted that the 7 and 8-year olds were able to recognize the change and delivered the correct response (that the rows were equal). When asked to justify their responses as to why they said the two rows are the same; some said,

"Because each object in the two rows had matching objects";

"the two rows had the same number of objects".

The results of this task illustrate that the children had some concept of the numbers and the change occurring to the numbers. The descriptions of their responses were symbolic; because they could tell from what the researcher did, for example, "You have added two shells…. here and not here". It showed Number and this includes items that show that the child counted, for instance, "there's only four here (yellow shells) and four here (blue shells)". The description showed Matching, the children matched one or more of the materials with ones on the other side, e.g., "the two rows have three shells each;" "there's a cup here and a cup here too". The children in this group exhibited One to One Correspondence; – they showed the ability to recognize that each member of a given set has only one unique match. When you count objects without "re-counting" you have automatically recognized the one to one numerical correspondence [7]. The null hypotheses was therefore accepted that the 7 and 8 year old children would have an easier time successfully completing the one judgment task on conservation on number.

Responses from the children from the two schools (Private and Public) were almost the same for the children. There was no significant difference in their performance at each stage since children 3-4 and 5-6 could not conserve. Whilst the 7-8 years responded correctly to the conservational task.

This study ties in also with the study by [14] four levels of conservation where in the first level (3-4), the child is unable to make an equivalent set. At the second level and third level (5-6), the child can create an equivalent set, but is unable to maintain the equality in the face of a perceptual change and is unsure of equality or cannot provide a reason. At the fourth level, the child recognizes that the quantity does not change and can provide arguments to substantiate his reasoning. Further, Piaget's theory of cognitive development proposes that operations or actions become more structured with increasing age with each new structuring. [6] supports Piaget in this respect by saying that from the point of view of the Piagetian system, the older child seems to have at his command a coherent and integrated cognitive system with which he organizes and manipulates the world about him. It is this system that makes the primary (7-8) school age child different from his preprimary (3-5) age counterpart.

8. Conclusion and Recommendation

Results gathered from this study are consistent with Piaget's observation on children's ability to conserve at the concrete operational stage. That the Ghanaian children tested were no different in their cognitive stage as with the Swiss children used by Piaget. The one judgmental task proposed by [29] in the line of questioning the children fitted with this study. This is because they did not have difficulty completing the one judgment task since there was no pressure for the children to gauge the researcher's intentions or intended response from the subject as in the Piaget standard test.

However, my study does not fit with Winer's linking hypothesis because Winer suggests that young children will be more successful in number conservation when given small numbers. This was not the case in my study, as almost all the 3-4-year olds were not able to conserve number. Even children given a small quantity of objects were not able to conserve, as a result, contradicting the linking hypothesis proposed in Winer's study. Again, this study support that of [1] who suggested that the children of ages 3 and 5 could not conserve in anyway. It was noted that the quantity order in which the child was assigned to did not make a difference in whether or not the child was able to conserve.

This finding may suggest that children ages 3-4 and 5-6 do not have the ability to conserve number in any manner. Further, Paget's theory of cognitive development proposes that operations or actions become more structured with increasing age with each new structuring. Hence, the teachers' understanding of the cognitive developmental stage will enable teachers to build a firm foundation on which later conceptual development of the children will build. This is possible if the concepts are taught at a time when a child is matured, enough to conceptualize what is expected.

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