HOOFSTUK 8

SAMEVATTING

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8.1 Doel van die ondersoek

Die doel van hierdie ondersoek was om 'n oplossing te probeer vind vir die probleem van onderprestasie in wiskunde gedurende die junior primêre fase. Dit was veral die doel om aan te toon dat kognitiewe faktore 'n belangrike oorsaak van leerprobleme in wiskunde is en derhalwe aan te dui dat leerlinge met leerprobleme in wiskunde, op 'n laer denkvlak is as leerlinge wat nie probleme in hierdie vak ondervind nie.

8.2 Literatuuroorsig

Om hierdie doel te bereik, was dit nodig om te weet wat die huidige siening is van die oorsake van leerprobleme in die algemeen. Eerstens is aangedui wat onder leerprobleme verstaan word. Op grond van verskillende definisies in hierdie verband, is tot die gevolgtrekking gekom dat 'n leerling geïdentifiseer kan word as 'n leerling met leerprobleme wanneer daar 'n duidelike diskrepans bestaan tussen sy werklike leerprestasie en sy leerpotensiaal (vgl. paragraaf 2.1). Die aandag is vervolgens gevestig op die verskeidenheid oorsake van leerprobleme in die algemeen (vgl. paragraaf 2.2). Die klem is veral gelê op ontwikkelingsprobleme as oorsaak van leerprobleme wat in die eerste plek geïnterpreteer moet word as onderontwikkeling in organiese opsig. Aan die anderkant openbaar ontwikkelingsprobleme hom ook in sake soos die rypheids- of gereedheidsfaktor, innerlike pubertering en dergelike (vgl. paragraaf 2.2.2.2).

Die oorsake van leerprobleme in wiskunde is in twee kategoriëë ingedeel, nl. eerstens die oorsake waar kognitiewe faktore nie 'n beslissende rol speel nie, en tweedens die oorsake wat veral betrekking het op die kognitiewe ontwikkeling van die kind.

In die eerste groep kan die algemene oorsake van leerprobleme ingesluit word, soos huislike omstandighede, motivering, ens., asook faktore soos interferensie, outomatismes, perseverasie, ens. (vgl. hoofstuk 3). Die leerhandeling in wiskunde vereis 'n intensioneel-rasioneel geleide ver= loop. Outonomie in die leerhandelingsverloop is dikwels verantwoordelik daarvoor dat selfstandige denke misken word.

In die tweede groep kom die kognitiewe faktore aan die orde. Die kog= nitiewe ontwikkeling staan in noue verband met die ontwikkeling van die getallebegrip.

Die stygende hiërargie van kognitiewe prosesse is belangrik vir die vorming van begrippe in wiskunde. Terwyl die kind begrippe van getal, ruimte, grootte en hoeveelheid vorm, gaan hy deur 'n reeks ontwikkelingsfases wat veral duidelik word uit die vermoë van die kind om te konserveer, te klas= sifiseer en reekse te vorm (vgl. paragraaf 4.3.1). Sodra 'n kind leer om logies te dink, is hy ook gereed om met formele werk in wiskunde te begin. Logiese denke word gekenmerk deur die omkeerbaarheid van die denke. Die denke van 'n kind in die voor-operasionele fase is nog nie omkeerbaar nie. Sy denke word nog begrens deur die onmiddellike perseptuele veld.
Die onderrig in wiskunde vir dié kinders is derhalwe betekenisloos en een van twee dinge sal gebeur: Die kind sal die leerstof verander in 'n vorm wat hy kan assimileer en gevolglik nie leer wat hy veronderstel was om te leer nie, of hy sal 'n spesifieke responsie leer wat geen stabili= teit besit nie en wat derhalwe nie veralgemeen kan word nie, met 'n ge=

volglike lae retensiepotensiaal. Onvoltooide operasionele denke blyk dus 'n belangrike oorsaak te wees van leerprobleme in wiskunde (vgl. paragraaf 5).

8.3 Empiriese navorsing

Die ondersoek het bogenoemde aangesluit om 'n antwoord te probeer vind waarom sekere leerlinge ten spyte van 'n bo-gemiddelde intellektuele ver= moë, leerprobleme in wiskunde in die junior primêre fase ondervind.

8.3.1 Metode van ondersoek

Die I.K.'s van al die Afrikaanssprekende graad I- en graad II-leerlinge in die komprehensiewe eenheid Potchefstroom is gedurende die derde en vierde kwartaal van 1973, bepaal. Altesaam 980 leerlinge is op hier= die wyse getoets.

'n Eksperimentele groep is tentatief saamgestel uit al die leerlinge met 'n I.K. van 108 plus wat in die Desember-eksamen (1973) binne die dertig persent swakste presteerders in wiskunde in die betrokke skool geval het. 'n Kontrole is tentatief saamgestel deur elk van die proefpersone in die eksperimentele groep af te paar met 'n leerling in dieselfde skool, van dieselfde geslag en met min of meer dieselfde I.K. en ouderdom, maar sonder leerprobleme in wiskunde.

Omdat die standaarde van skole en onderwysers wissel, is aan al die leer= linge wat die tentatiewe eksperimentele- en kontrolegroep gevorm het, 'n gestandaardiseerde rekenkundetoets gegee. Hierdeur is 'n hele aantal

proefpersone uitgeskakel, sodat die finale aantal proefpersone tagtig was, d.w.s. veertig in die eksperimentele groep en veertig in die kon= trolegroep. Die gemiddelde I.K.'s van beide groepe was 115,8.

Om die denkvlak van bogenoemde proefpersone te bepaal, is agt verskillen= de denkvlaktoetse op die proefpersone indiwidueel toegepas. Die denk= vlaktoetse het veral die vermoë van die proefpersone om te konserveer, klasse te vorm en reekse te vorm, aangedui (vgl. paragraaf 6.4.4).

8.3.2 Resultate van die ondersoek

Die ondersoek het die volgende belangrike bevindings blootgelê:

(a) Proefpersone wat leerprobleme in wiskunde ondervind, is op 'n laer denkvlak as die proefpersone wat nie leerprobleme in hierdie vak onder= vind nie (vgl. paragraaf 7.2). Dit is derhalwe duidelik dat ten spyte van 'n kwantitatiewe ooreenkoms in die intellektuele vermoë van die proef= persone in die eksperimentele- en kontrolegroep, daar 'n duidelike kwali= tatiewe verskil in die intellektuele vermoëns is, ten gunste van die proefpersone in die kontrolegroep.

(b) Konservasie van kontinue hoeveelhede en klassifikasie, differensieer die beste tussen leerlinge met leerprobleme in wiskunde en leerlinge son= der leerprobleme in hierdie vak. (Vgl. paragraaf 7.2).

Konservasie en klassifikasie is dus belangrike denkhandelinge om sukses van leerlinge in wiskunde te voorspel.

(c) Daar bestaan 'n goeie korrelasie tussen subtoets 2 van die gestandaardi= seerde wiskundetoets en die verskillende denkvlaktoetse (vgl. paragraaf 7.3).

(d) Daar is 'n ontwikkeling in die denke van leerlinge vanaf graad II tot standerd I, (Vgl. paragraaf 7.4). Dit is dan ook in ooreen=stemming met Piaget se kognitiewe ontwikkelingsteorie en die bevestiging daarvan deur verskeie resente navorsers, nl. dat die denke ontwikkel met ouderdomstoename, .

(e) Die ondersoek het ook aangedui dat daar ander faktore as intellek=tuele vermoë en ouderdomstoename is wat 'n bydrae lewer tot die denkont=wikkeling van die kind (vgl. paragraaf 7.4). Dit impliseer dat ouder=dom en I.K. nie die enigste kriteria vir 'n skoolgereedheidsondersoek be=hoort te wees nie.

(f) Dogters is op 'n hoër denkvlak as seuns van dieselfde ouderdom. (Vgl. paragraaf 7.5). Dit kan dus verwag word dat seuns meer leerpro=bleme in wiskunde in die aanvangsklasse sal hê as dogters.

8.4 Implikasies en aanbevelings

Bogenoemde resultate hou noodwendig implikasies in t.o.v. voorskoolse onderwys, die toelating van vyf-jariges in die primêre skool, kurriku=lumbeplanning, die meting van intelligensie en hulpverlening aan leer=linge met leerprobleme in wiskunde.(Vgl. paragraaf 7.7). Dit word der=halwe aanbeveel dat:-

(a) Vyfjariges slegs bywyse van uitsondering en slegs na 'n deeglike on=dersoek na skoolrypheid en skoolgereedheid, in graad I toegelaat behoort te word. Die enigste regverdiging vir die toelating van vyfjariges is om dit as 'n metode van versnelling t.o.v. besondere begaafde leerlinge te beskou.

(b) Geen formele onderrig in wiskunde toegelaat behoort te word alvo= rens die leerlinge nie kognitief daartoe in staat is nie. Die denkont= wikkeling van die leerlinge behoort dus eers bepaal te word voordat met formele onderrig in wiskunde begin word.

(c) Onderwyseresse moet deeglike studie van die denkontwikkeling van die kind moet maak en onderwysmetodes dienooreenkomstig moet aanpas.

(d) Besondere hoë eise aan die organisasie van wiskunde-onderwys gestel moet word. Wiskundelaboratoriums waar elke kind die geleentheid gebied word om voorwerpe te manipuleer en te klassifiseer behoort die ideaal van elke onderwyseres en skool te wees.

8.5 Aanbevelings ten opsigte van verdere navorsing

8.5.1 Opstel van 'n ontwikkelingskaal

Navorsing t.o.v. die psigometrisering van Piaget-toetse behoort onderneem te word. Hierdie toetse kan dan aanvullend by die huidige intelligensie= meting gebruik word.

8.5.2 Uitbreiding van hierdie ondersoek

(i) Hierdie ondersoek behoort ook uitgebrei te word na leerlinge met leerprobleme in wiskunde in die senior primêre fase.

(ii) 'n Opvolgstudie behoort meer lig te werp op die invloed van ouderdoms= toename, geslag, omgewing en die skool op die kognitiewe ontwikkeling van die kind.

8.5.3 Hulpverlening aan leerlinge met leerprobleme in wiskunde

Die feit dat verskeie navorsers positiewe resultate gevind het met die onderrig van sekere konservasie-tegnieke, bied ongetwyfeld moontlikhede vir ortodidaktici om hierdie terrein te ondersoek met die oog op hulpverlening aan leerlinge met leerprobleme in wiskunde.

SUMMARY
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1. Introduction

This study has been undertaken to try and find an answer to the problem of underachievement and the failure rate among the pupils in the junior primary phase of education. It has been aimed mainly at showing that cognitive factors play an important part in causing learning problems in mathematics.

Firstly, I have tried to point out what is meant by learning problems. It has been decided that because of different definitions in this regard, a pupil with learning problems can be identified when there is a discrepancy between his actual achievement and his learning potential. Special attention has therefore been directed at the variety of reasons for learning ~~ning~~ problems in general. Emphasis is especially placed on developmental problems as a cause of learning problems. In the first place developmental problems must be interpreted as organic underdevelopment. On the other hand developmental problems may show themselves in matters such as maturity, the readiness factor, or the intrinsic puberty process, etc. The maturity level is the product of a biological developmental process, and it is something which the child must develop on his own as time passes. Being ready for school is an all embracing concept which includes the school maturity level. School readiness also refers to the influence of learning on a child's development, up to the stage where one can expect a child to make good progress at school.

The causes of learning difficulties in mathematics can be divided into basically two categories : Firstly where cognitive factors do not play a

decesive rôle; and secondly the category which is especially concerned with the cognitive development of the child. The general causes of learning difficulties such as home-background, motivation, etc., and other factors such as interference, automatisms, perseveration, etc., can be included in the first category cognitive factors are dealt with in the second cate= gory.

As it is the aim of this study to show that pupils with learning difficul= ties in mathematics, operate on a lower cognitive level than pupils with= out this particular defect, it has been necessary to discuss thoroughly the cognitive development of the child with special reference to the transi= tion from the intuitive to the concrete-operational phase.

2. COGNITIVE FACTORS

2.1 Two approaches to intelligence

There are some differences with respect to the concept of intelligence which is employed both by Piaget as a developmental psychologist and by psycholo= gists whose orientation is the psychometric assessment of individual dif= ferences. In psychometric terms, the course of mental growth is plotted as a curve which measures the amount of intelligence at some criterion age that can be predicted at any preceding age. Such curves do not prove anything with regard to the quality of knowledge at given age levels.

2.2 The Piagetian approach

2.2.1 Introduction

The Piagetian view, is that mental growth is not a quantitive but rather a

qualitive affair and presupposes significant differences between the way of thinking of children and adolescents as well as between pre-school and school-age children.

Development is described by Piaget as an invariant sequence of stages of intellectual development through which all children must pass and which "emerge" because of the interaction of two components, genetically determined: maturation and experience (learning). Maturation as a component in the developmental process, is seen as placing functional limits on the effects of training and experience. That is, training designed to induce a "cognitive" behaviour more complex than that already characteristic of the child, is expected to have no effect if the child is not maturatively ready. Essentially Piaget distinguishes between two developmental stages within the period spanning the ages two and eleven or twelve:-

(i) The pre-operational stage

It marks the beginning of language in the form of words.

(ii) The concrete operational stage

This stage is particularly important to the primary school teacher because during most of the time that children spend in the primary school they are in this stage of development.

There are four factors involved in the transition from one stage to another. They are maturation, experience, social transmission and equilibration. The last factor, equilibration, is an active process involving a change in one direction being compensated for by a change in the opposite direction.

Piaget's message for pre-school education is clear, i.e., behaviour characteristics of the stage of concrete operations cannot be induced (trained)

if the child is in the pre-operational stage (ages two to five). The Piagetian theory suggests that it is impossible to alter the sequence of developmental change or to bring about extremely rapid change.

2.2.2 The transition from the pre-operational to the concrete-operational phase

The aspects which play an important rôle in the transition from the intuitive to the concrete-operational phase are as follows:

* the degree of flexibility of retro-action;
* the degree of flexibility of anticipation;
* the degree of flexibility between retro-action and anticipation;
* the methods used by the child in his actions, namely the ascending or descending method.

Although the transition is statistically very difficult to measure, it is possible to get a good indication by a careful observation of the child's working methods.

2.2.3 The development of the concept of number

The construction of number goes hand in hand with the development of logic. Logical and arithmetical operations therefore constitute a single system. While the child is developing concepts of number, space, size and quantity, he is passing through a series of developmental stages which are the product of his physical and intellectual development. These stages of development become especially apparent in the ability of the child to conserve, classify and seriate. As soon as the child is able to reason logically, he is at the stage where formal mathematics will be of benefit to him.

The aforementioned operations will be discussed briefly.

2.2.3.1 Conservation

The concept of conservation was formulated by Piaget and has been defined as the realization of the principle that a particular dimension of an object may remain invariant under changes in other, irrelevant aspects of the situation. The lack of realization of this principle is considered a manifestation of the immature level of functioning of the child's mental processes and of his failure to conform to the operational structure of logical thought.

The understanding of number has been described as lending itself particularly well to investigation of the development of conservation. This has specifically involved the measurement of children's ability to grasp the equivalence or non-equivalence of the elements in a set, irrespective of their arrangement. Previous research has shown that tests of number conservation may be a meaningful measure of arithmetic readiness.

The problem children have with the conservation of number is seen in a display such as:

O O O O O

□ □ □ □ □

The child would agree that there was one-to-one correspondence, but if one set of counters is spread apart, the idea of one-to-one correspondence is lost. The child at the pre-operational stage is fooled by perception.

3.2.3.2 Classification and seriation

The method of classification and seriation follows an age progression.

In classification the children less than six years old, make some sort of graphic display of the objects. They are unable to classify the objects in accordance with some property such as colour, shape or size.

The main difference between the operational classification and the gra= phic classification found at the first stage, is that the child who is more mature is very much more flexible in the way he handles the elements. At the level of graphic collections there is neither anticipation nor even hindsight, so the subject cannot reconcile new dimensions with an existing classification. As development goes on, so do the possible rearrangements become increasingly systematic in character. They do so because there is hindsight, and then there is anticipation.

The transition from the pre-operational to the concrete-operational stage can be studied by the method of construction followed by the child. Where a child begins with a successive manipulation of the objects, he is na= turally led to apply the ascending method; and, conversely, when he tries to anticipate a result without arranging the objects, he tends to hit upon the descending method first.

Piaget maintains that both class (in logic) and number result from the same operational mechanism of grouping and that the one cannot be fully understood without the other. Addition is an operation that relates the parts to the whole or renames the whole in terms of its parts ($3 + 2 = 5$; $5 = 3 + 2$).

Reversibility of thought is necessary for the "additive" concept. If the child knows that $3 + 2 = 5$, is he also able to solve $3 + \square = 5$? This problem requires reversibility of thought and is a rote or verbal activity for the children in the pre-operational stage.

Seriation is not operational until about the same age as classification. The operational schema of seriation is necessarily anticipatory. The subject knows in advance that by choosing the smallest element among those that remain, he will eventually build a series in which each term is larger than the preceding ones.

While ordination and cardination ideas are different, each involves the other. Piaget maintains that ordination always involves cardination and cardination always involves ordination.

The idea of ordering numbers (2 comes after 1 and before 3) is necessary in order to determine the cardinal number of a set.

Concrete operational thought requires the co-ordination of cardinal and ordinal number. Two limitations - incomplete differentiation between quality and number, and semi-operational processes confined to the perceptual plane - are a sufficient explanation of the fact that during the pre-operational stage there is no systematization and generalization of the co-ordination between cardinal and ordinal. At this level a cardinal whole exists only so long as it is perceived as such; if it is decomposed, the whole is destroyed which means that the position of each element in the series cannot yet be translated immediately into a cardinal value.

Problems such as $5 = \square + \square$ or $\square + \square = 5$, have no meaning for the children in the pre-operational stage and should be deferred.

These children are also still unable to generalize $N + N$ as $2 \times N$, etc. At the concrete-operational stage the child immediately understands the multiplicative relationship that exists as $2 \times N$ and can generalize the operation to other problems if more sets are considered.

It is very likely that teachers are teaching mathematical ideas before the child can understand them.

3. EMPIRICAL STUDY

3.1 Objective

The aim of this study was to find an answer to the question of why certain pupils in the junior primary phase, in spite of their above average intellectual abilities, experience learning difficulties in mathematics.

3.2 Method

The I.Q's of all Afrikaans speaking grade I and grade II pupils in the Potchefstroom comprehensive unit, was determined during the third and fourth terms of 1973. Altoghether 980 pupils were tested.

An experimental group of pupils was assembled, consisting of pupils with I.Q.'s of 108 plus who in the December examinations of 1973, were within the weakest category of 30% in mathematics. A controlled group of pupils was assembled, by taking one of the pupils from the experi=

mental group and matching him with a pupil from the same school, of the same sex and with basically the same I.Q. and age, but who did not have learning difficulties with mathematics.

Because the standard amongst schools and teachers varies, a standard= ized test was given to all the pupils in the experimental and control= led groups. By using this method, the sample was reduced to 80, that is to say 40 in the experimental group and 40 in the controlled group. The average I.Q. of both groups was 115,8.

To determine the mental level of the abovementioned group, eight dif= ferent mental level tests were applied to each member of the group. These tests would show the ability of the pupil to conserve, classify and seriate.

3.3 Results

The study revealed the following:-

(a) Pupils with learning problems in mathematics, operate on a lower mental level than those who did not have this problem. It became es= pecially clear, that despite a quantitive similarity in the intellec= tual abilities of both samples, there was a definite qualitive diffe= rence in the intellectual ability of the samples which favoured those members of the controlled group.

This finding is of importance to our schools, who tend to stress the

inter-individual comparison of I.Q. results (the difference between the I.Q.'s of pupils). The I.Q. result should therefore be examined with a qualitive analysis in mind, in other words, an intra-individual comparison.

(b) A study of the pupils' ability to conserve continuous quantities and classification is the best method in differentiating between those pupils with learning problems in mathematics and those without the problem. Conservation and classification abilities are therefore important methods in forecasting the success of pupils in mathematics. This implies that:

(i) classification and conservation are of special diagnostical value in determining whether a child is ready for working with numbers in the initial school year;

(ii) teaching methods used to teach conservation and classification play an important part in accelerating the development of the number concept;

(iii) conservation and classification techniques can be used successfully as a therapeutic aid with primary school children who have learning difficulties with mathematics;

(iv) there was a good correlation between subtest (2) of the standardized mathematics test and the different mental level tests. The good relation between subtest (2) and the mental level scale can be accounted for by the fact that subtest (2) tests the child's concept of number;

(v) there is a development in the mental level of a child between grade II and standard I. This is in agreement with the developmental theory of Piaget, and which has been confirmed

by numerous recent researchwokers namely, that the mental process, develops with age. The question now arises as to whether learning difficulties in mathematics are not a result of the too early admittance of pupils to primary schools, or to the too early teaching of formal mathematics;

(vi) the study also shows that there are more factors, besides intellectual ability and age, which contribute to the mental development of the child. It implies that I.Q., and age are not the only criteria to be taken into account when investigating whether children are ready for school or not;

(vii) it seems as if girls are on a higher mental level than boys, therefore it can be expected that more boys than girls will suffer from learning difficulties in mathematics in the primary school.

3.4 Implications and recommendations

The abovementioned findings are significant for teaching in the pre-school stages, the admission of five-year olds to grade I, the planning of curricula, the methods measuring intelligence and the assistance given to pupils with learning difficulties in mathematics.

It is therefore recommended that:-

(i) Only in exceptional cases should five-year olds be admitted to grade I and then only after a thorough investigation has been made to determine the child's maturity and his school readiness. The only justification in allowing a five-year old to attend school is when it is used as a method of acceleration in regard to the gifted child.

(ii) No formal mathematics should be taught unless the child is cognitively prepared. The mental development of the child must be determined before a start is made with formal mathematics.

(iii) Teachers should have a clear understanding and appreciation of the child's cognitive development, and should adapt his teaching methods accordingly. Teachers of the grades and standard I pupils must for example, give the pupils the opportunities to manipulate concrete objects so that they will be able to discover for themselves the relationship between objects. True learning only takes place when the child can interpret the abstract connection in mathematics.

(iv) Very high demands must be placed on the organisational factors. Each teacher should aim at creating a mathematics laboratory in which each child would have the opportunity of manipulating and classifying objects.

(v) The measuring of intelligence, should be supplemented with a series of Piaget projects. This quantitative-qualitative measurement of the intelligence capabilities of the child should be of much value in diagnosing learning difficulties.

(vi) The fact that a number of researchworkers have achieved positive results in training conservation techniques, holds certain possibilities for research by ortho-didacticians into the field of assisting pupils with learning difficulties in mathematics.