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ABSTRACT

Field experience during teacher preparation enables the prospective teacher to observe children as they develop -- emotionally, socially, intellectually, and physically. Children, at different stages of development, exhibit characteristics of behavior which may or may not affect how and what they learn in the formal classroom environment. Thus, the teacher must be able to relate pedagogy to the developmental level of each child. The assignment described concerns mathematics instruction in the early childhood grades and is based on the implications of Jean Piaget's research and writing regarding a basic in the development of numerical understanding--the ability to conserve number. The assignment involves administering three to four Piagetian-type tasks to a child, analyzing the child's responses according to Piagetian theory, noting the relationship between the child's cognitive skills and mathematics ability, and planning a program in mathematics instruction based on the child's apparent level of cognitive functioning. The prime significance of this assignment lies in the prospective teacher's questioning, probing, and discussion of the child's responses and, thus, a refinement in the teacher's understanding of children's thinking skills. (JMF)

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Mathematics Education in Early Childhood: Focus on the Developing Child

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Introduction

Prior to the conceptualization of field-based, competence-based teacher education programs and their implementation, preservice teacher training programs were largely conducted in college classrooms, except for the student-teaching component. There the emphasis was on theoretical understandings needed for effective teaching and learning in the classroom. With the advent, however, of field-based, competence-based programs in teacher education, field experiences - observing and working with teachers and children in actual classrooms - provide the setting for integrating theory with practice. Such programs afford the prospective teachers, throughout their education sequence, the opportunity of putting theory into immediate practice to test its usefulness and applicability not only to their current teaching assignment but also to their developing philosophy of teaching.

Field experience during teacher preparation also enables the prospective teacher to observe children as they develop - emotionally, socially, intellectually, and physically. Children, at different stages of development, exhibit characteristics of behavior which may or may not affect how and what they learn in the formal classroom environment. Thus, not only must the teacher be versed in sound pedagogy, s/he must also be able to relate pedagogy to the developmental level of each child. Field experiences of a specific nature can help the prospective teacher establish this relationship between pedagogy and child development.

Illustration: Mathematics Education in Early Childhood

As an instructor of early childhood mathematics education in Brooklyn College's performance-based program for the education of teachers, the writer has found one assignment particularly useful in helping prospective teachers develop competence in relating pedagogy to a child's level of cognitive development. The rationale for this assignment is based on the implications of Jean Piaget's research and writing with regard to mathematics instruction in the early childhood grades.

Piaget maintains that basic to the development of numerical understanding is the ability to conserve number (Piaget, 1964). A child can conserve number when he understands that "a group of eight objects continues to be equal in number to a second group of eight objects, even with a transformation in the space occupied by the objects" (Lavatelli, 1970, p. 106). If a child cannot conserve number, a characteristic of the preoperational child, it is questionable whether he truly recognizes cardinality - the "whatness" of a number. Since his perceptions dominate his thinking and he can focus on only one characteristic of an object or group of objects at a time, he might claim that "three is greater than five" if the five objects are grouped close together and the three objects are spread apart. A child at this stage of development, the preoperational, cannot reverse his thinking, that is, in considering the equation $5 - 3 = \square$, he cannot recall he originally added 2 to 3 to get 5. These characteristics - inability to conserve number, irreversibility of thought, and focusing on one attribute of an object at a time - definitely affect how and what the preoperational child learns with regard to mathematical understandings, concepts, and skills taught in the early childhood grades.

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The child who is beginning to develop logical thought processes is classified as concrete operational in his thinking. He can conserve number, reverse his thought processes, consider two attributes of an object simultaneously, and can think associatively, that is, he understands that 3 + 5 is the same as 4 + 4. A child at this stage of cognitive development is capable of far more mathematical understanding and competence than the preoperational child. Thus, it is important that the teacher knows at what stage of development a child is so that s/he can provide the child with experiences in mathematics learning appropriate to the level of development.

Tasks designed by Piaget and others to assess characteristics of children's thinking are useful indicators of stages of cognitive development (Almy, 1966; Lavatelli, 1970; Piaget, 1964; Sharp, 1969). As such, they can aid pre-service or inservice teachers in assessing children's levels of cognitive development and thus, direct their teaching to where each child is in terms of his or her cognitive ability to learn new skills or acquire new understandings.

The assignment referred to earlier as an example of how, in a field-based, competence-based teacher education program, pedagogy can be related to child development, involves the following: administering three to four Piagetian-type tasks to one child, analyzing the child's responses according to Piagetian theory, noting the relationship between a child's cognitive skills and mathematics ability, and planning a program in mathematics instruction based on the child's apparent level of cognitive functioning. Students choose their own tasks from recommended sources, select one child from the classroom in which they are doing their field experience, administer the tasks according to prescribed instructions, and record the child's response to each task and their subsequent analysis of these responses in the form of a log.

Prospective Teachers' Logs

Sample material from prospective teachers' logs is quoted here to illustrate how this type of assignment can help them gain insight into children's thinking and cognitive development.[1] The material collected demonstrates how such insights can guide the teacher in planning experiences suitable to a child's level of development.

Prospective Teacher A

Child: Age - 6 Grade 1

Task: Conservation of quantity

I gave Thomas a ball of modeling clay and asked him to make another exactly like it - just as big and just as heavy. After he finished making the other ball of clay which he felt was just like the first, I took one of the balls and rolled it out to look like a sausage. I asked Thomas, "Do the two pieces of clay have the same amount of clay now?" and "How do you know?"

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[1]My sincere thanks to the following students for their permission to quote from their logs: Ms. Joan Ginsberg, Ms. Linda Pultusker, and Ms. Ester Simanowicz. The names of the children are fictitious.

Child's Response:

The sausage has more clay because it is longer.

Analysis:

The results of the tasks I performed on Thomas point out that he is in the preoperational thought stage.... Thomas could not conserve quantity. He could not recognize that quantity is conserved even though its appearance may change, provided nothing is added or taken away.

The sausage "looked" longer, therefore it seemed to acquire more clay to Thomas even though he began with two balls of clay that were equal.

Child's Mathematics Ability:

Thomas's concept of number is unstable. He must use physical objects or pictures and then count them one by one to perceive number. If the objects are separated or rearranged, Thomas may change his mind about how many there are and will have to count them again. Since he cannot conserve number yet, he has trouble understanding the meaning of addition.... He can parrot the fact that 2 + 3 = 5 but he doesn't readily know what that means. When I place two objects down in one position and three objects in another, and then have Thomas put the objects together in one pile, he changes his mind about how many objects he had before and after the transformation.

Suggested Mathematics Program:

When teaching Thomas, I would use concrete apparatus and materials to provide manipulative and sensory experiences. I would use objects and/or pictures to keep Thomas actively involved and aware.

I would provide Thomas with a variety of instructional aids such as rods, disks, tiles, counters, etc. First I would let him explore these materials. Then I would plan learning activities which would lead to conversations and discoveries about size, shape, number relationships, equalities and inequalities. Hopefully, sufficient experiences in making one-to-one correspondences will provide the foundation upon which the ability to conserve number will develop.

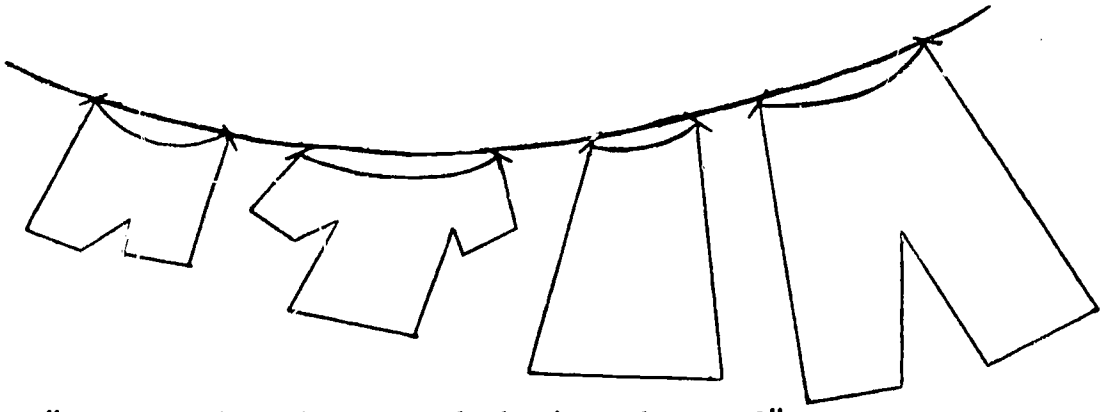
Prospective Teacher B

Child: Age - 9 Grade 2

Task: Seriation according to size

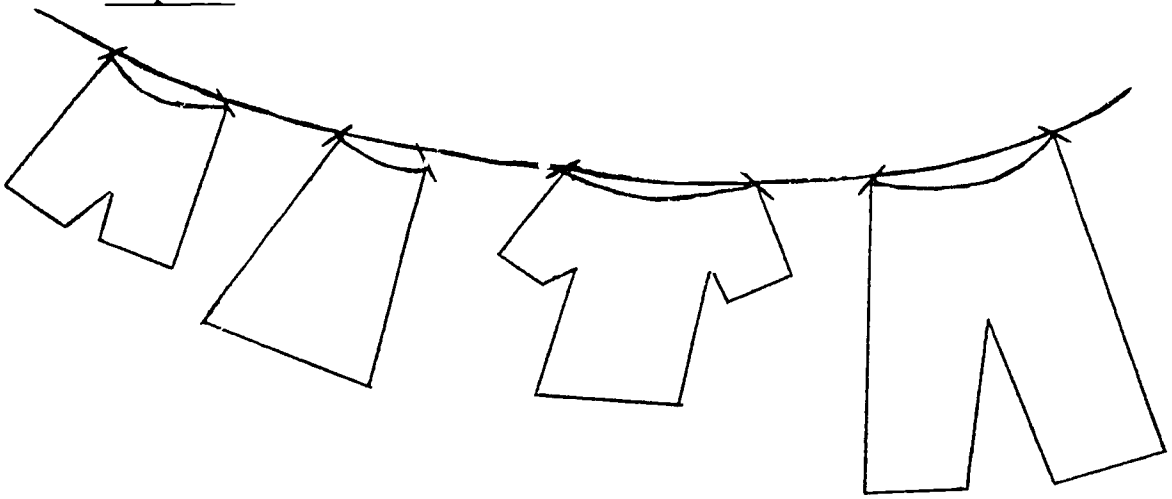
The materials were a set of paper doll clothes (two of each item which I cut out and painted) and two equal lengths of string.

First Sean matched the items (dresses to dresses, shirts to shirts, etc.). Then I took my set of clothes and placed them on the string saying, "I'm going to hang out my clothes on the line like this":



"Can you make a line that looks just the same?"

Response:



Analysis:

Sean found it difficult to seriate according to size as shown in the task where I asked him to hang up his "wash" to look like my "wash." He did not grasp the order concept well which is another characteristic of the preoperational child. The pre-operational child is unable to consider two variables simultaneously. For example, he cannot comprehend that an object can be to the right of one object and to the left of another at the same time. So it was with Sean who did not pick up the relative order of each object on the clothesline.

Child's Mathematics Ability:

Sean had difficulty with a lesson we did on ordinals (first through fifth). He did not seem to be able to grasp the order concept.

He did satisfactorily a lesson we had on "more than" and "less than." He did much better where there was a physical representation of

objects such as three chairs compared to five chairs or six pencils compared to one pencil. He could not understand, however, how a number could be less than one number and more than another number at the same time.

Suggested Mathematics Program:

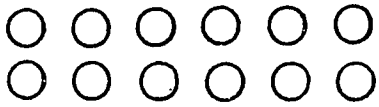
I would allow for repeated activities in seriating. We would line up several objects, see what order they were in, and then Sean could practice lining up objects in a similar fashion. If Sean is unable to seriate and see relationships between ordered physical objects, then he certainly will not be able to see the relationships between ordered numerals which are merely symbols. Once he can seriate easily, we can begin work on the number line and see that, just as the objects we lined up were in order, so the numerals on the number line are in a specific order.

Prospective Teacher C

Child: Age - 5 1/2 Kindergarten

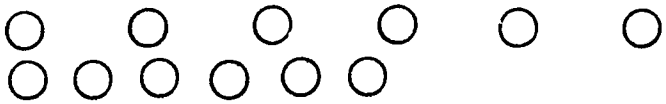
Task and Response: Conservation of number

Using 12 similar buttons, I placed the buttons on the table in two evenly spaced straight rows of six.



Question: How many buttons do we have in each row?
Response: Six buttons in each row.

Next I moved the buttons as such:



Question: Does each row have the same number of buttons now?
Response: No. The top row has more. It goes from here to here (showing with hands). It looks bigger.

Analysis:

Robert is at the preoperational stage of cognitive development. He is unable to conserve number. He was able to count (by rote) six buttons in each row and then set up one-to-one correspondence to see that the rows were equal. When the buttons were rearranged spatially, he told me there were more buttons in one row because that row took up "more" space. "More" for Robert was the apparent quantity (space occupied) rather than the actual number of buttons.... It is this conservation concept that is necessary for any real understanding of number.

Child's Mathematics Ability:

Robert has supposedly learned the number facts for sums up to seven, but in my opinion he does not understand these facts. He does not recognize the cardinal value of a number.

He is unable to work out mathematical problems unless he uses concrete materials. For example, to find the sum for 3 + 2, he needs to use blocks, pencils, or some other concrete objects.

Suggested Mathematics Program:

Robert's class is presently studying addition and subtraction of numbers up to five. I do not feel that Robert is ready for this work.

To help Robert develop an understanding of cardinal number, I would provide him with additional activities in comparing sets through one-to-one correspondence. These activities help develop the concepts of "equivalence," "more than," and "less than." Such concepts are necessary for understanding cardinality.

Robert also needs further experience in matching names for numbers (numerals) to the correct number of objects. Puzzle cards, or games such as Lotto or Bingo could be used to provide variety in the types of activities used.

Growth in Teaching Competence

While completing this assignment, a certain refinement appears to take place in the prospective teacher's understanding of children's thinking skills and in their attitude toward teaching young children. The prospective teachers are intrigued by the unexpected responses they receive from individual children. It is one thing to read about how four- or five-year-olds can be illogical in their thinking. It is more impressive, however, to actually hear such children make statements that to the adult are illogical and inconsistent. For example, a four-year-old has just counted a row of six chips and has made a second row of six chips matching the first row exactly. He insists there are six chips in each row. However, when the teacher rearranges the second row of chips so that it occupies more space than the first row, this same child may now insist that there are more chips in the second row.

Such responses cause the prospective teacher to question her own understanding of how children think and learn. With questioning, probing, and discussion, the realization begins to dawn that such an understanding is necessary for effective teaching. A more patient and tolerant attitude toward children accompanies this understanding in that the child is seen as an individual at a particular stage in development, thus capable of learning only what s/he is ready for. There is no labeling, and individual differences are truly respected.

Role of the Teacher-Educator

Throughout this experience the teacher-educator, both in the college seminar and the field setting, functions as a resource, a guide, and a supervisor.

As a resource s/he provides the prospective teacher, through lectures, demonstrations, and discussions, with pertinent theory which can readily be applied in a classroom setting. How such theory can be put into immediate practice is also discussed and demonstrated.

As a guide the teacher-educator helps the prospective teacher develop greater awareness of the growing child through individual conferencing following on-site visitations and observations of the prospective teacher's interaction with individual children. The accessibility of the teacher-educator in the field setting allows for increased individual guidance.

As a supervisor in the field setting the teacher-educator evaluates the prospective teacher's analysis of children's development and determines whether subsequent teaching is indeed directed to the child's apparent stage of cognitive development. Alternative strategies and materials are suggested where necessary to make teaching more consistent with children's ability.

Conclusion

The particular assignment described in this paper uses experience in the classroom (the field-based aspect of a teacher education program) and theory to develop an important teaching competence - relating pedagogy to child development.

Too often in the past, the prospective teacher has studied child development in one course and teaching methods in another. Pedagogy and child development were treated as separate subjects, with little opportunity given to integrate both for more effective teaching and learning in the classroom. The prospective teacher might be knowledgeable about the appropriate methods and materials to use in teaching beginning reading, and also be quite competent in applying this knowledge in an actual classroom setting. However, if the lesson planning has not taken into account the varied developmental levels of her students, cognitive or other, the teacher's efforts may have little impact upon the students' growth - intellectually, socially, or emotionally.

The teacher-educator today has an important responsibility in helping the teachers of tomorrow develop competence in integrating theory with practice in their focus on the developing child.

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