STUDY ON DEVELOPMENTAL STAGES AND IMPORTANT PERIODS OF PROBABILITY COGNITION FOR CHILDREN AGED 6-14

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***Abstract**: This study chose 906 children aged 6-14 as the subjects and focused on the development stages and important periods of probability cognition. The study shows that probability cognition of children aged 6-14 experiences the following 5 stages: slow development stage I (6-7 years old), rapid development stage I (8-9 years old), slow development stage II (10 year old), rapid development stage II (11-12 years old) and stagnant stage (13-14 years old). Additionally, there are 2 important periods in children's cognitive development: 8-9 years old is the first important period and 11-12 is the second important period. Even at the highest development stage, children can just understand the "number representation", "random distribution" and "fraction representation" while can't reach the mastery level, which suggests the limitation of children's probability cognition. Accordingly, curriculum should take children's cognitive development level into account and set reasonable cognitive objectives.*
***Keywords**: Children; Probability cognition; Developmental stage; Important periods*

INTRODUCTION

Probability literacy is one of the core mathematics literacy for current citizens (Gal, 2002). "Mathematics Curriculum Standards for Compulsory Education (Experimental Edition)" (China Ministry of Education, 2001)" published in 2001 organized probability related knowledge as a content branch in the compulsory curriculum and determined the cognitive objectives for the first time. However, studies (Gong & Song, 2006; Gao, 2011) show that teachers can't adapt to its requirement, and specifically, teachers lack of probability related knowledge and encountered various difficulties in teaching.

In view of the above issues, "Mathematics Curriculum Standards for Compulsory Education (2011 Edition)" (China Ministry of Education, 2011) (hereinafter refers to "Curriculum Standards (2011 Edition)" published in 2011 initiated certain adjustments and revisions to reduce the content and lower the difficulty. But, what are the theoretical and practical basis of these revisions? Actually, this issue involves a key question: what are the development stages and levels of children's probability cognition? A widely shared principle in educational psychology is stated by Ausubel (1983), "the most important factor to influence learning is the student's previous knowledge. We ought to discover it and to teach consequently". Only based on the data from psychology and define children's cognitive development stage on the concept of probability can we solve the problems in curriculum and resolve the disputes.

Specifically, this study focuses on the following 2 issues: (1) The cognitive development stages and levels on probability for children aged 6-14; (2) The important periods.

DESIGN

Questionnaire

The questionnaire involves 4 sets of questions and each question contains 5 cognitive tasks which refers to cognition of randomness, cognition of random distribution, a rough cognition of probability comparison (hereinafter refers to rough cognition), number representation of probability (hereinafter refers to number representation), fraction representation of probability (hereinafter refers to fraction representation).

questions	cognitive tasks
An opaque box contains a white ball, a black ball and a green ball, and they are the same except for color. Close your eyes and shake the box, and then take out 2 balls simultaneously from the box, and please answer:	For the 2 balls have been taken out, Task 1: are they certainly the situation of "1 white and 1 black"? Task 2: how many possible situations totally? Please list all the possible situations. Task 3: please compare the probability of the situation of "one black and one green" and "one white and one green". Task 4: if we put back 2 balls, shake the box, and then take out 2 balls repeatedly for 10 times, please estimate the times that "one white and one green" will be taken out. Task 5: please describe the probability of "one white and one green" in fraction.

Table1: Questionnaire for probability cognition (example)

Subjects

The experimental group. 906 children of K-8 grades (6-14 years old, and each age contains about 95 children) from 27 classes were chose as the subjects, and all the subjects are stratified sample from urban, suburban and rural areas.

The control group. To eliminate the impact of learning to children's probability cognitive development, we choose children from other schools which haven't learned probability related knowledge as the control group which contains 2 age groups: one is 9 years old (67 children) and the other is 11 years old (66 children).

CONCLUSION

Reliability and Validity

Cronbach α coefficient among the 5 cognitive tasks are between 0.70-0.870, which shows that the questionnaire has comparatively high homogeneity reliability.

Correlation coefficient among the 4 sets of questions are all in significant level (0.28-0.716), which shows that the questionnaire has comparatively high Construct validity.

Developmental Stages and Important Periods of Probability Cognition

Cognitive development stages

The following table and figure shows the descriptive statistics of the scores for the 4 sets of questions (Table2, Figure1).

Age	Number	Average score	SD	Min	Max
6	95	6.73	3.227	0	13
7	90	6.91	2.799	0	12
8	88	9.11	1.956	4	13
9	106	11.66	2.736	3	17

10	108	12.23	2.650	0	17
11	107	13.55	2.156	8	18
12	102	14.84	3.178	6	20
13	99	14.73	3.090	5	20
14	111	14.02	2.569	4	20

Table 2: Descriptive statistics of the scores

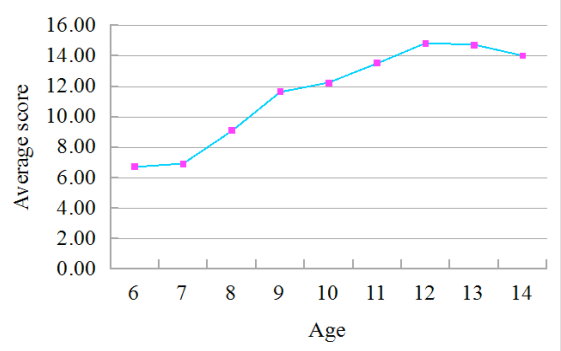

Figure1:Scoring average figure of probability cognition for children aged 6-14

We set age as independent variable and probability cognition as dependent variable and conduct One-way ANOVA. The results show that Welch (8, 370.568) = 124.739, P<0.001, which suggests there are significant differences between different age groups in terms of probability cognition. Specifically, multiple comparison test shows that apart from 6 and 7, 9 and 10, 11 and 13, 11 and 14, 12 and 13, 12 and 14, 13 and 14 years old, there are significant differences between other age groups ($P < 0.05$).

Accordingly, we can conclude that children's probability cognition experience 5 developmental stages:

Stage 1 ($6 \leq Age \leq 7$): Slow development stage I. According to the standard that 20%, 50% and 80% respectively serves as the description of preliminary understanding, understanding and mastery (Shen & Liu, 1984). Children aged 6-7 have understood randomness and acquired preliminary knowledge of "rough cognition", "number representation" and random distribution.

Stage 2 ($7 < Age \leq 9$): Rapid development stage I. Children in this stage have mastered randomness and understood random distribution, "rough cognition", "number representation" and "fraction representation".

Stage 3 ($9 < Age \leq 10$): Slow development stage II. Children aged 10 scored 0.57 higher than that of 9 years old, while there is no significant difference between the 2 groups.

Stage 4 ($10 < Age \leq 12$): Rapid development stage II. This is another rapid development period while the development rate (1.3) is lower than the other one (2.375). Compared to children aged 10, 11-12 ones have mastered randomness and "rough cognition", and have understood "number representation", random distribution and "fraction representation". Specifically, there is no further development in the cognition of random distribution and "fraction representation".

Stage 5 ($12 < Age \leq 14$): Stagnant stage. There is no significant difference in cognitive level between 13-14 and 10-11 years old children, and from a larger extent, the cognition of probability for

children aged 11-14 are roughly in the same level.

Important periods

As mentioned above, 7-9 and 10-12 are 2 rapid development stages, and whether the 2 stages are the important periods? To answer this question, we should exclude the influence of learning. The 9 and 11 years old subjects from experimental groups have learned preliminary probability related knowledge, while the control groups haven't learned any probability knowledge in school. ANOVA between experimental groups and control groups shows that there is no significant difference between the 2 groups. Accordingly, we can exclude the influence of learning and conclude that 9 and 11 years old are 2 important periods of children's probability cognitive development.

DISCUSSION AND SUGGESTION

Even at the highest development stage, children can just understand the "number representation", "random distribution" and "fraction representation" while can't reach the mastery level, which suggests the limitation of children's probability cognition. Accordingly, curriculum should take children's cognitive development level into account and set reasonable cognitive objectives.

References

Ausubel, D. I., Novak, J. D., & Hanesian, H. (1983). *Psicología educativa. Un punto de vista cognoscitivo*, Mexico: Trillas.

China Ministry of Education. *Mathematics Curriculum Standards for Compulsory Education* (Experimental Edition)[S]. Beijing Normal University Press, 2001. [In Chinese].

China Ministry of Education. *Mathematics Curriculum Standards for Compulsory Education (*2011 Edition)[S]. Beijing Normal University Press, 2011. [In Chinese].

Gal, I. (2002). Adult statistical literacy: Meanings, components, responsibilities. *International Statistical Review, 70* (1), 1-25.

Gao, H. (2011). *The understanding of probability concepts in 6-12 year old pupils*[D]. Master's thesis of Hangzhou Normal University, Hangzhou, 2011.[In Chinese].

Gong, Z. & Song, N. (2006). Teaching and learning of statistics and probability: reflections and suggestions. *People's Education, 10,* 1-6. [In Chinese].

Shen, J., & Liu, F. (1984), Study on the cognition of volume for children aged 5-17[J]. *Acta Psychologica Sinica, (2)*: 155-164. [In Chinese].