Potential Predictability of ZPD of Children's Cognitive Development

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Abstract

Obtaining information on whether the child has the potential for growth is not an easy task. Research shows that using different matrix like Raven or different batteries in a static way cannot be indicative of children further development. This study attempts to probe the potential predictability of children's performance during Dynamic Assessment of their Future development. 41 children between ages 3 to 6 years old participated in this study. The data in pretest, ZPD, and posttest were converted into Rasch Measure. The results of different analysis indicate that relying on children's actual performance cannot be an indicative factor of their development in the future.

Keywords: Dynamic Assessment, Rasch Measure, Raven Test, Cognitive Development.

1. Introduction

Assessing young children is a challenging job especially when it should be carried out dynamically (Haywood & Lidz, 2007; Lidz, 2003). According to Haywood and Lidz (2007), the nature of metacognitive function activated by DA is not well documented. They believe that this type of brain functioning emerges in young children at ages as young as three. Because of such emerging nature, it would be worthwhile to explore the nature of possible effect of DA in young children.

There are different ways to measure children's growth. Poehner and Lantolf (2005) classify different ways of measuring respondents' growth into three ways: (1) estimating the difference score, (2) focusing on qualitative change of individual learners from their first performance, and (3) emergence of novelty in respondents. Kester, Pena, and Gillam (2001) believe that growth or ZPD can be measured through estimating the range between unsupported and supported performance. Still others believe that there are three indicative factors in determining kid's growth: quality and quantity of change; the kids' amount of effort, and the child's responsiveness (Jitendra, Rohena-Diaz and Nolet, 1998)

One way is to use Application of Cognitive Functions Scale (ACFS) (Haywood & Lidz, 2007; Lidz, 2003). ACFS can be use with children between ages of 3 and 5. It is one of a curriculum based assessment instruments to measure children's cognitive growth at this range of age. Lidz (1991) has combined ACFS with process-based approaches to create a DA models. ACFS functions on six subscales of classification, short-term auditory memory, short-term visual memory, sequential pattern completion, perspective taking, and verbal planning. In classification, the child is required to sort blocks into groups in terms of one of the features of the material like color, shape, size, etc. in short term auditory memory part, the child is required to retell the story either immediately after the assessor or with delay. In short term visual memory task the child is required to remember eight pictures that are placed before his sight and then removed from his sight. In sequential pattern completion task, the child is required to complete the sequence of pattern started

by the assessor by placing the appropriate the plastic geometric shape in its place. Perspective taking is the same as symbolic play in which the kid can take the role of his teacher and to communicate in the same way. In verbal planning task, the child is required to talk about a plan like making a specific food he knows.

Children are measured on this kit through seven scales (Haywood & Lidz, 2007)

1. Self-regulation: child maintains attention and refrains from impulsive interaction with materials;
2. Persistence: Child completes task without seeking to terminate prematurely;
3. Frustration Tolerance: When experiencing frustration, the child is readily calmed and redirected;
4. Motivation: Child shows enthusiastic reaction to the materials and task;
5. Flexibility: Child does not repeat unsuccessful task solutions and develops alternative approaches to the task;
6. Interactivity: child engages in turn-taking conversational exchanges with some degree of elaboration;
7. Responsively: Child is a willing learner and open to input from the assessor. (pp. 100-101)

Another possible way of measuring children's growth is to use Raven's Standard Progressive Matrices (RSPM) which is in three forms of Standard Progressive Matrices, Colored Progressive Matrices, and Advanced Progressive Matrices. Colored -progressive matrices is especially used for young children. It has a colored background to attract kid's attention. Boucal and Bond (unpublished paper) have used the test to measure children's actual and potential abilities in solving the progressive prompts. They compared children's function in pretest and posttest of two experimental and control groups. Experimental groups were provided with five stage intervention on some other items they selected from the test. Accordingly, grade five is given to the most independent child on the given task and zero is given when the child cannot solve the task even with maximum assistance.

Other scholars believe that learners' growth should be measured by the difference of their performance on pretest and posttest for each child (Baek & Kim, 2003), ZPD score is the difference between pretest and posttest for each child. Elsewhere, Campione and Brown (1987, as cited in Gutiérrez-Clellen & Pena, 2001) assert that the success and failure of DA is determined by learners' ability to transfer their learning to new tasks. To Poehner (2008), mediation can be formulated as a continuum of activity being implicit at the beginning and explicit at the end.

2. Zone of Proximal Development (ZPD)

Many criticisms are recently leveled at traditional static testing. Johnson, Mattheos, Savingby and Attstrom (2007) believe that static testing or assessment cannot predict learners' future development. Furthermore, as Hasson and Joffe (2007) state, static assessment fails to provide us with information about the processes learners undertake to solve a problem. Whereas obtaining children's actual knowledge is an important issue, what is more essential and indicative information in children from clinical stands is how much the child has the potential for growing in terms of cognition and language. Children's potential for growth can sometimes be the essential indicative factor in diagnosing many developmental problems like autism, disorder attention, and developmental delay.

Dynamic assessment (DA) is believed to an efficient way to screen those who have acceptable future development from those that would not. The method is based on Vygotsky's (1978) idea on how child's cognition develops. According to Vygotsky (1986), child cognitive development occurs at two levels of potential or assisted (present to future) and actual and unassisted (past to present). At the actual level, the child does the task without any help (autonomous level), whereas at the potential level the child needs another person's assistance (a mediator) (Vygotsky, 1986, 1978).

One of the important features of DA is the teaching phase (Kester, Pena, & Gillam, 2001). Mostly this teaching phase is classified into two possible binary situations as "structured" versus "mediated" (Kester, Pena, & Gillam, 2001, p. 43), interventionist versus interactionist approaches (Poehner & Lantolf, 2005), or Sandwich versus Cake (Sternber & Riorenko, 2002 as cited in Poehner, 2008). The idea is that mediation either can be predetermined in advance (structured) or emerges as the result of learner and knower's interaction. Interventionist approach has followed test-teaching-retest procedure (Kester, Pena, & Gillam, 2001).

The distinctive feature of Vygotsky's theory is Zone of Proximal Development or ZPD (Lantolf, 2006, 2002; Ohta, 2000; Roebuck, 2000; Swain, 2000; Thorne, 2000; Van Lier, 2000). ZPD refers to the difference between what a person can achieve when acting alone (unassisted) and what s/he can accomplish when acting with support from some other persons and / or cultural artifacts (assisted).

The scope of ZPD includes more than just expert/ novice interaction; people working jointly are able to co-construct contexts in which expertise emerges as a feature of the group (Lantolf, 2000). To Lantolf (2006), ZPD is more appropriately conceived of as collaborative construction of opportunities. According to Ellis (1999), ZPD encompasses three types of objectives: (1) "goals that learners can meet without help;" (2) "those that are completely beyond the learners even if assistance was available;" and (3) "goals that the learner can perform if she/he has access to meditational assistance" (p. 20). To Ohta (2000) ZPD refers to the internalization of social interactive processes happens within the zone of proximal development (ZPD). He believes that "Determining a learner's ZPD is an act of negotiated discovery that is realized through dialogic interaction between learner and expert. In other words, the learner and expert engage each other in an attempt to discover precisely what the learner is able to achieve without help, and what the learner can accomplish with assistance… importantly, the help negotiated between the novice and expert is graduated and contingent in the sense that it moves from more explicit to more implicit, or strategic, levels, and is offered only when needed and is withdrawn once the novice shows signs of self-control and ability to function independently." (p. 55)

3. Dynamic Assessment with Young Children: Reported Research

Children's growth has been the main concern of many papers in the first language acquisition field of study (Bensoussan, 2002; Brooks, 1997; Levy, 1999; Lidz, 2003; Shurin, 1998; Malowitsky, 2001). Children's growth is projected to nine areas of cognition, learning ability, social interaction, play, communication, adaptive behavior, behavior characteristics, motor skills, and sensory sensitivity (de Boer, 2011). These areas are expected to grow harmoniously and in balanced way.

Shurin (1998) has studied 26 four year old children. Five children from among this number have developmental disabilities. She found that through intervention these kids were able to show considerable growth in four areas of classification, perspective taking, verbal planning and sequential pattern completion. Elsewhere, Brooks (1997) finds that working with 22 preschool children diagnosed with disability would result in were able to improve in classification subscale of the ACFS. Bensoussan (2002), in another study, used Auditory Memory, Verbal Planning, and Perspective Taking subscales ACFS to investigate the possible effect of practicing on 20 children between the ages of 3 and 4 years old. She found that children in experimental group performed significantly better on the posttest comparing with those in control group.

In another study, Boucal and Bond (unpublished paper) have used the Raven Progressive Matrices to measure 120 children between ages 8 to 12 years old using pretest, posttest control group design. The experimental group has been provided with DA on some of the items from Raven test. The test is similar to the sequential pattern completion part of ACFS. They found out that experimental group shows a better result on posttest.

ZPD in Relation with Baseline Score

Those practicing DA believes that learners' actual level of development cannot predict their success in future or future level of development. They believe that different learners or children

with similar ALD might have different potentiality or ZPD. As was stated earlier "DA is an approach to assessment and instruction derived from Vygotsky's theory of the [ZPD]" (Poehner & Lantolf, 2005, p. 233).

Ableeva (2008), in his research on reading and listening comprehension finds that the individuals' different ZPDs are indicative factors in determining their different levels of attainments. Elsewhere, Fuchs et al. (2008) emphasize that ZPD can be indicative of individual differences of those with similar low score. Kester, Pena, and Gillam (2001), also, find that preschool children through mediated learning can perform on vocabulary task better than those in control group. Kozulin and Grab (2001) find a negative high correlation between pretest and posttest in experimental group. They conclude that pretest cannot be a good predictor of learners' future development.

Although many research enquiries on DA indicate the important effect of dynamic intervention on learners' future development, this area of research is still very new. More research in this area can possibly shed more light into the true nature of learners' competence in second language acquisition in general and of children's cognitive growth in particular. With this in mind, we have attempted to investigate the possible relationship between children's level of actual development (LAD), their ZPD, and their Level of Future Development (LFD).

4. The Purpose of the Present Study

It is widely believed that kids' level of actual development (LAD) ability can improve through Adults' dynamic intervention (Ableeva, 2008; Baek & Kim, 2003). Many studies proves that intervention, if properly used, can have a fundamental effect on the expansion of children's potential ability (Boucal & Bond, forthcoming; Fuchs et al., 2008; Kozulin & Grab, 2001). Boucal and Bond especially attempt to investigate possible role of ZPD on children's later performance in Belgrade. The purpose of present research is to investigate whether children's ZPD can predict their performance on posttest in comparison with children LAD. To this end, the following questions were posited:

1. Is there any significant relationship between children's LAD and ZPD?
2. Is there any significant relationship between children's Future Development and ZPD?
3. Which of the Children's Level of Development (ZPD or LAD) can predict their Future Level of Development?

5. Method

Participants

46 Iranian Kids ranging from 3 to 6 years old in Setaregan Kochak Kindergarten in Tehran were participated in this study. They were 23 female and 24 male. 6 kids were absent from either posttest or dynamic intervention stage, so they were omitted from the final analysis. The total number subjected to analysis packages was 41 (22 female and 19 male). Table 1 shows the distribution of kids in terms of gender and age.

Table 1 Kids' distribution across Gender and Age.

Gender						Age					
Female		Male				3-4		4-5		5-6	
Number	%	Number	%			Number	%	Number	%	Number	%
22	53.7	19	46.3			10	24.4	19	46.3	12	29.3

From among 41participants of this study 37 kids were reported to be fluent in their mother tongue and 4 are almost fluent in their mother tongue. Moreover, these kids were assessed in terms of their learning ability as being low (5), moderate (8), good (18), and very good (10).

Instruments

In this study, Raven's Standard Progressive Matrices (RSPM) test for kid version was used as pretest, dynamic test, and posttest. It is an IQ test for kid upper than age 7. It consists of 60 items that their difficulty is progressively increased. From among 60 items we chose those items which are easier for kids less than 7. The reason was that the test includes items that lend itself both to kids' cognitive level and variability. As is shown in Table 2, the minimum score on 12 items in both pretest and posttest is well above average score (6). This shows that the selected items are appropriate for this range of age. Test items selected for pretests and posttest were items number 1, 2, 5, 9, 12, 14, 16, 19, 22, 23, and 25. Items used for Dynamic Assessment were 3, 6, 13, 15, and 20.

Table 2 Descriptive Statistics of Kids' Performance in Pretest and Posttest

	N	Minimum	Maximum	Mean	Std. Deviation
Posttest	41	.00	8.00	4.5366	1.62938
Pretest	41	.00	9.00	3.5366	2.13422

Children's LAD equals their performance on the pretest. To measure ZPD, we used Boucal and Bond's (forthcoming) design. Therefore, to estimate ZPD, we grade kids' performance as follows:

0 = unsuccessful kid in responding the question even with help;
1- successful kid with second help (Cognitive 2);
2- successful kid with first help (Cognitive 1);
3- successful kid with just encouragement (Motivational Help);
4- unaided individual in answering the question

Children's Future Development equals their performance on the same test (pretest) as posttest one month later after intervention.

Procedure

The study took place at Setaregane Kochak Kindergarten in Tehran. One week after pretest, kids were assessed dynamically on five items chosen from RSPM. First the kids were to answer each item individual without help (unaided response). When they failed in solving the task, they were given the second chance (motivational help) in the way that the assessor encourages them to think once more (Boucal & Bond, forthcoming). In the case they failed this time, children were given implicit cue to solve the problem through giving hint about the relations between pictures in the rows of the task (cognitive 1) and then between pictures in the column of the task (Cognitive2). When this stage was finished, we assessed the children on the posttest (Future Development) one month later.

6. Data Analysis and Results

To answer the questions addressed in this study, different analyses were employed. Rasch Model was used for several purposes: Screening the data, Preparing the data, and the main analysis. First, both pretest and posttest were subjected to Winstep to estimate their possible mis-infit and mis-outfit. Table 3 shows that all items function appropriately as all infit and outfit indices are less than 2 except with item 16 with misoutfit more than 2 but as the Zstd is less than 2 the item can be accepted as well functioning item.

Rasch item reliability indices of pretest and posttest are 0.79 and 0.88 respectively. This shows that the selected items function consistently in this sample.

The second use of Rasch model was to prepare data. Fuchs et al.(2008) as well as Boucal and Bond (forthcoming) and Birjandi, Daftarifard, and Lange (2010) did not use raw scores in their analysis. Instead, they changed the raw score either to Z score (Fuchs et al., 2008) or Rasch measure (Boucal & Bond, forthcoming).

Table 3 Item Statistics: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item	G
16	4	41	.70	.54	1.24	.7	2.04	1.5	A	-.15	.23	90.2	90.2	B	B
10	6	41	.20	.46	1.23	.8	1.93	1.7	B	-.03	.27	85.4	85.4	A	A
11	13	41	-.91	.36	.91	-.5	1.44	1.7	C	.36	.34	80.5	71.7	A	A
18	11	41	-.65	.37	1.18	1.0	1.22	.8	D	.13	.33	68.3	75.2	B	B
14	23	41	-2.08	.34	1.14	1.2	1.21	1.3	E	.20	.37	58.5	66.5	B	B
7	11	41	-.65	.37	1.10	.6	1.14	.6	F	.21	.33	73.2	75.2	A	A
8	16	41	-1.28	.34	1.07	.6	1.13	.7	G	.27	.36	68.3	67.0	A	A
3	19	41	-1.63	.34	.91	-.8	1.09	.6	H	.43	.36	75.6	64.7	A	A
19	6	41	.20	.46	1.00	.1	1.06	.3	I	.26	.27	85.4	85.4	B	B
1	14	41	-1.04	.35	1.02	.2	.97	-.1	J	.33	.35	70.7	70.0	A	A
15	12	41	-.78	.37	1.01	.1	.96	.0	K	.33	.33	68.3	73.4	B	B
5	7	41	.00	.44	1.01	.1	.87	-.2	j	.29	.28	82.9	83.0	A	A
12	29	41	-2.82	.37	1.01	.1	.93	-.2	i	.36	.36	70.7	73.7	B	B
22	24	41	-2.20	.34	.98	-.1	.99	.0	h	.38	.37	70.7	67.4	B	B
20	12	41	-.78	.37	.94	-.3	.82	-.6	g	.42	.33	73.2	73.4	B	B
4	7	41	.00A	.44	.93	-.2	.92	-.1	f	.36	.28	82.9	83.0	A	A
17	25	41	-2.31	.34	.88	-.9	.82	-1.0	e	.50	.37	73.2	68.1	B	B
2	30	41	-2.96	.38	.87	-.6	.80	-.7	d	.49	.35	78.0	75.5	A	A
6	14	41	-1.04	.35	.80	-1.5	.75	-1.2	c	.56	.35	80.5	70.0	A	A
9	8	41	-.18	.42	.79	-.9	.62	-1.0	b	.53	.30	85.4	81.0	A	A
13	40	41	-5.88	1.03	.77	.0	.15	-.6	a	.44	.15	97.6	97.6	B	B
MEAN	15.0	41.0	-1.03	.48	.99	.0	1.04	.2			77.1	76.1		
S.D.	9.7	.0	1.71	.33	.13	.7	.40	.9			8.8	8.5		

In this study, we used Rasch measure for several reasons. First, Rasch measure gives intervals, "whereas raw score gives order" (Bond, 2010, personal communication). Second, Rasch measure equalized scores in number and scores became comparable. Third, where as raw scores are "strongly non-linear at the extremes", Rasch measures are not (Linacre, 2010, personal communication). To do so, each person's Rasch measure was obtained for each task separately (including both Pretest and Posttest).

Analysis One: Descriptive Statistics

As mentioned earlier, Rasch measures of item were subjected to analyses because they are both linear and interval. Table 4 summarizes means and standard deviation of both raw score and Rasch measure. As is shown in this table, learners' performance has improved in posttest (M = 3.53, SD = 2.13 in Pretest, and M = 4.53, SD = 1.62 in posttest).

Table 4. Descriptive Statistics for Total Group

	Raw Score		Rasch Measure	
Variables	M	SD	M	SD
Pretest	3.53	2.13	-1.84	1.14
Posttest	4.53	1.62	-1.83	1.14

Note: SD = Standard Deviation; M = Mean for total sample.

As was mentioned earlier, to estimate children's ZPD, we followed Boucal and Bond's (forthcoming) design. This means that kids capable in doing the task alone have got the complete score of 4, and those required help have got 3 (when are successful with motivational help), 2 (when are successful with cognitive 1 as hint), and 1 (when are successful with the second help or cognitive 2). In the case they were not able to answer the question with maximum help, they got zero ZPD.

Analysis Two: Correlation

To answer the first and second question of this study, "(1) Is there any significant relationship between children's LAD and ZPD?" and "(2) Is there any significant relationship

between children's Future Development and ZPD?", two correlations performed between Children's LAD (Prettest) and ZPD and between Future Development and children's ZPD (Table 5). As was mentioned earlier, the data of pretest, ZPD, and posttest were subjected to Rasch model separately using Winisteps to obtain Rasch measure for each person. Then, Pearson product moment correlation between children's LAD, ZPD, and Future Development obtained to investigate if children's hierarchical ordering has changed through mediation. Table 5 summarizes the results.

Table 5. Children's LAD, ZPD, and Future Development Rasch Measure Correlation

	LAD	FD
LAD	1	
FD	0.148 (0.356)	1
ZPD1	0.311* (0.048)	0.287 (0.069)
ZPD2	0.320* (0.041)	0.273 (0.08)
ZPD3	0.279 (0.078)	0.422** (0.006)
ZPD4	0.270 (0.088)	0.279 (0.07)
ZPD5	0.219 (0.170)	0.356* (0.02)

Note: LAD is the same as pretest; FD is children's future development and is the same as posttest; ZPDs are children Zone of proximal development on five items. All Measures are in Rasch.
* . Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed).

As is shown in table 5, there is no significant correlation between children's performance on pretest (LAD) and posttest (FD). This means that children's performance have changed through mediation; some has growth unexpectedly better than others. Such an unexpected growth leads to inconsistency of among the rank orders of children on Raven Test across times. That is, some kids should have had a better potential for improvement than others. Interesting point is that LAD (Pretest) is significantly correlated with ZPD1 and ZPD2 but not with ZPD3, ZPD4, and ZPD5. This indicates that children have changed after receiving more intervention dynamically. Also Table 5 shows that children's performance on posttest (FD) is significantly correlated with ZPD3 ($r = 0.422$, $P < 0.01$), and ZPD5 ($r = 0.356$, $P < 0.05$). This indicates meaningful consistency of among the rank orders of children on Raven Test posttest and ZPD3 and ZPD5. The correlational results indicate that with more intervention, children's performance may remain more consistent over tests.

Analysis Three: Regression

To answer the third question of this study, "which of the Children's Level of Development (ZPD or LAD) can predict their Future Level of Development?" one multiple regression analysis through the Stepwise method was employed to investigate which of the children's performance (LAD, ZPD1, ZPD2, ZPD3, ZPD4, and ZPD5) can predict their Future Development (Posttest). Multiple-regression is a linear regression with two or more independent variables. Also through stepwise method which is the combination of two methods of backward and forward selections, independent variables are added to the equation one by one and subsequently might be removed when they do not contribute significantly to regression. The results are shown in tables 6, 7, and 8.

One of the essential assumptions that should be met in regression analysis is the linearity of the data. The result of the analysis of variance (ANOVA) shows that regression model is linear; $F(1, 39) = 8.429$, $P < 0.05$ for model 1 and $F(2, 38) = 8.648$, $P < 0.05$ for model 2. Moreover, Scatter plot shows (Figure1) that there is no funnel shaped or crescent shaped cloud. This indicates that two assumptions of linearity and homogeneity of variance have been met.

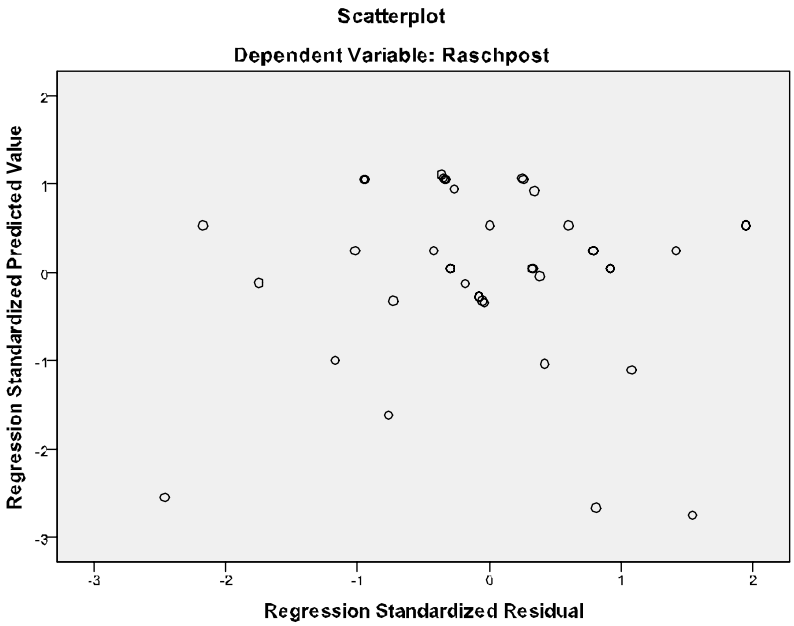

Figure 1
Scatter Plot of Standardized Residual by Standardized Predicted Value

Table 6 shows the regression model that are extracted are ZPD3 and ZPD1. The total R reported in this analysis for model 1 is 0.422 with R Square of 0.178. This means that ZPD3 can predict children's future development with 17.8 percent in the present sample. Also this amount increases by 31.3 percent when ZPD1 is added in the second model. This indicates the importance and power of intervention provided to children on Raven test.

Table 6. Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.422(a)	0.178	0.157	1.05063
2	0.559(b)	0.313	0.277	0.97302
a Predictors: (Constant), ZPD3 b Predictor: (Constant). ZPD3, ZPD1				
c Dependent Variable: Posttest				

7. Conclusion

It is widely believed that DA has a fundamental effect on the expansion of children's potential ability (Ableeva, 2008; Baek & Kim, 2003). The purpose of present research is to investigate whether children's ZPD can predict their performance on posttest in comparison with children LAD, and whether there are any significant relationships between children's LAD, ZPD and Future Development.

The result of the study indicates that children's performance in posttest improved. Also, lower standard deviation in posttest for both tasks indicates that children are more homogeneous after mediation. Lack of correlation between pretest and posttest can indicate that children were responsive differently to mediation.

In this study, we found no significant correlation between children's performance on pretest (LAD) and posttest (FD). This shows that children's rank order in posttest has changed. Some children have shown more unexpectedly growth in respect with their performance on pretest. As was stated earlier, some kids have shown more or less potential for improvement than others. Interesting point is that LAD (Pretest) is significantly correlated with ZPD1 and ZPD2 but not with ZPD3, ZPD4, and ZPD5. This indicates that children have changed after receiving more intervention dynamically.

Further research might focus on the possible hierarchical ordering among different cognitive hints and children's growth. As stated by Birjandi, Daftarifar, and Lange (2010), DA research needs to explore the effects of different types of mediation and different ordering of hints on learners' improvement.

The result of regression was interesting. ZPD1 and ZPD3 could predict about 30 percent of children's performance on the posttest. Pretest does not form a regression model for this sample. This indicates that one cannot make decision about children's cognitive stand from static point of view. Children's ability can be more obvious if they work with a know how instead of working alone. This is especially important when diagnosis for certain disabilities matters. Another research might compare children with specific language or developmental problem with normal children on their ZPD. More studies are required to investigate the nature of ZPD in relation with many other cognitive and psychological factors.

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