

# Appendix A

## Native Numbers Objectives and Sequence of Instruction

Concepts	Activity & Representation	Learning Objective
Number Concepts	Rods	Map number names to continuous quantities
	Sets	Map number names to discrete quantities
	Match Rods	Map continuous & discrete representations of same quantity
	Numerals	Map number names to their symbolic numerals
	Mastery	Match numbers across representations
Number Relations	Rods	Map vocabulary for number to continuous quantities
	Sets	Map vocabulary for number to discrete quantities
	Tally Marks	Map relational concepts to tally marks
	Numerals	Map vocabulary to symbolic numerals
	Mastery	Match numerical relations across all representations
Number Ordering	Rods	Order relative position/magnitude of whole numbers
	Sets	Order relative position/magnitude of whole numbers
	Tally Marks	Order relative position/magnitude of whole numbers
	Numerals	Order relative position/ magnitude of whole numbers
	Mastery	Map position/magnitude across all representations
Counting	One-to-one	Ordinal numbers; tag objects with numbers
	Count Up	Cardinal numbers: count objects to tell “how many”
	Count Down	Count backwards to 1, starting from numbers up to 9
	Count On	Add two numbers by starting with the larger number
	Mastery	Count out a given number of items from a larger set
Demonstrate Mastery	Numbers	Match numbers across representations
	Numbers+	Recognize quantities accurately and quickly
	Order	Order across representations
	Counting	Cardinal counting up and down
	Counting+	Given a starting amount count out objects

# Appendix B

## Active Control Math Center Games

### Manipulatives

**Geometry:** GeoBoards and GeoBands, Polydrons, Magnatiles

**Number and Operations:** Unifix Cubes, Counting Bears

- **Math Games**

**Q-Bitz:** symmetry, visual dexterity, spatial reasoning and memory

<https://www.amazon.com/MindWare-44002-Mindware-Q-bitz/dp/B0031P91LK>

- **Spill the Beans:** Divide a sheet in half. Grab a handful of transparent counters. Drop them on top of the divided paper. Estimate how many counters were on each side. Group them in a way that makes sense; compare sides.
- **Top-it:** Shuffle a deck of cards and pass them out to each player equally. Players turn over a card and call out the number. The player with the highest card wins and takes both cards.
- **Addition Top-it:** Same as above but each player takes two cards.
- **Double Digit Top-it:** Each player turns over two cards and makes the largest possible double-digit number. The player with the largest number wins.
- **How Many Am I Hiding?** Starting with 10 objects one player hides an amount behind their back (or under an object) and then places the remainder of the counters in front of them and asks, "How many am I hiding?" The second player counts what they can see and uses strategies to figure out how many counters are hidden.
- **Count and Compare Dots:** Using ten frame dot cards and a board divided into three sections with the symbols  $>$   $=$   $<$ , players draw a ten-frame dot card, compare their cards and then place their card on the correct section of the board. Alternately players divide the cards into two groups: cards with 0–4 dots and cards with 5–10 dots. Each player turns over a card and together they add the dots to get the sum.
- **Beat You to Five:** Using a spinner with numbers 1–5, spin and collect Unifix Cubes to build towers up to five. Extend by spinning and removing cubes to get to 0 and building up to ten.

### Activities as Supplemental Extensions from Project-based Learning

Menus with prices; measuring cups; cups for stacking, counting, measuring, and estimating

## Appendix C

### Imputation Statistics and Syntax

Table C.1 *Descriptive Statistics of Paired Differences Between NSS3, LOCF, and Imputations of NSS3*

Replacement	<i>M</i>	<i>SD</i>	<i>SE</i>	<i>t</i>	<i>df</i>	Sig*
NSS3 Original and LOCF	0.36	1.93	0.31	1.16	38	0.25
First Imputation and LOCF	0.60	2.11	0.31	1.92	45	0.06
Second Imputation and LOCF	0.47	2.06	0.30	1.53	45	0.13
Third Imputation and LOCF	0.53	2.09	0.31	1.73	45	0.09
Fourth Imputation and LOCF	0.49	1.94	0.29	1.72	45	0.09
Fifth Imputation and LOCF	0.43	1.98	0.29	1.48	45	0.15
Pooled and LOCF	0.50		0.31	1.63	1415	0.10

*Note.* LOCF = last observation carried forward; NSS3 = Number Sense Screener™ (Jordan et al., 2012) third testing point (i.e., the maintenance scores of the first-treatment group). The last observation carried forward included the post-test scores of seven participants from the first-treatment group who were missing the third measure, the maintenance measure. Multiple imputation was carried out using SPSS for MAC version 26 using the three measurement time points (NSS1, NSS2, and NSS3) of the Number Sense Screener™ (Jordan et al., 2012) for both groups ( $n = 46$ ).

\* $p < .05$

### Syntax for Multiple Imputation of Missing Data

#### \*Impute Missing Data Values.

```
MULTIPLE IMPUTATION NSS1 NSS2 NSS3
/IMPUTE METHOD=AUTO NIMPUTATIONS=5 MAXPCTMISSING=NONE
/MISSINGSUMMARIES NONE
/IMPUTATIONSUMMARIES MODELS
```

#### SPLIT FILE

```
LAYERED BY Imputation_.
SORT CASES BY Imputation_.
SPLIT FILE LAYERED BY Imputation_.
T-TEST PAIRS=Imputation_ WITH NSSPostLOCF (PAIRED)
/ES DISPLAY(TRUE) STANDARDIZER(SD)
/CRITERIA=CI(.9500)
/MISSING=LISTWISE.
```

### R Syntax for Corrections of the Pooled Means

```
# Equation (2) U_bar
U_m <- c(.312, .304, .307, .287, .291)
U_m <- U_m^2
M <- 5
U_bar <- sum(U_m)/M

# Equation (3) B
Q_bar <- .504
Q_m <- c(.599, .467, .533, .492, .430)
B <- (1/(M-1))*sum((Q_m - Q_bar)^2)

# Equation (4) T
`T` <- U_bar + (1 + (1/M))*B

# Equation (7) upsilon_sharp
upsilon_sharp <- (M-1)*(1 +
(U_bar/((1+(1/M))*B)))^2

# Equation (8) upsilon_star
upsilon_com <- 45
upsilon_star_com <- (upsilon_com +
1)/(upsilon_com + 3)*upsilon_com
upsilon_obs <- (1-(((1 +
(1/M))*B)/(T)))*upsilon_star_com
upsilon_star <- 1/((1/upsilon_sharp) +
(1/upsilon_obs))
```

## Appendix D

### Descriptive Statistics for Motivation and Mathematical Language

**Table D.1.** Descriptive Statistics of the Young Children's Academic Intrinsic Motivation Inventory

Test/Period	First-Treatment Group ( <i>N</i> = 24)			Wait-Control Group ( <i>N</i> = 22)		
	<i>M</i>	<i>Mdn</i>	<i>SD</i>	<i>M</i>	<i>Mdn</i>	<i>SD</i>
Pre-Test Reading	24.42	25.00	5.31	25.41	26.50	4.97
Post-Test Reading	25.92	29.00	5.98	26.32	27.50	5.58
Pre-Test Math	25.29	27.00	4.06	24.55	24.50	3.22
Post-Test Math	26.92	27.00	2.73	25.91	27.00	3.84

*Note.* Young Children's Academic Intrinsic Motivation Inventory (Gottfried, 1990)  
For the modifications in the current study, the highest score possible was 33 and the minimum was 11.

**Table D.2.** Descriptive Statistics for the Preschool Assessment of Mathematical Language

Test Period	First-Treatment Group ( <i>N</i> = 24/17 <sup>a</sup> )			Wait-Control Group ( <i>N</i> = 22)		
	<i>M</i>	<i>Mdn</i>	<i>SD</i>	<i>M</i>	<i>Mdn</i>	<i>SD</i>
PALM 1	15.38	16	0.82	14.68	15	1.46
PALM 2	15.42	16	0.72	15.27	16	1.42
PALM 3 <sup>b</sup>	15.42 / 15.53 <sup>b</sup>	16 / 16 <sup>b</sup>	0.78 / 0.80 <sup>b</sup>	15.59	16	0.59

*Note.* The maximum score is 16.

<sup>a</sup>The first number reflects the total in the group before removing the seven participants who did not have a maintenance test; the second number is the number after removing the seven participants.

<sup>b</sup>The first number reflects statistics for the group before removing the seven participants; the second number is with the seven participants removed.

# Appendix E

## Syntax for Differences Between 13 Participants Who Did Not Complete 25 Activities to Level 5

### SUMMARIZE

```
/TABLES=PretestBoth PosttestBoth TotalDays DaysAt22 NSSChangeScore Group BY ID
/FORMAT=VALIDLIST NOCASENUM TOTAL LIMIT=100
/TITLE='Case Summaries'
/MISSING=VARIABLE
/CELLS=COUNT.
```

### T-TEST GROUPS=Group(1 2)

```
/MISSING=ANALYSIS
/VARIABLES=PosttestBoth
/CRITERIA=CI(.95).
```

## Number Sense Screener™

### \*Examining Normality

```
EXAMINE VARIABLES=NSS1 BY Group
/PLOT BOXPLOT HISTOGRAM NPLOT
/COMPARE GROUPS
/PERCENTILES(5,10,25,50,75,90,95)
HAVERAGE
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING REPORT
/NOTOTAL.
```

```
VARIABLES=NSS1 NSS2 NSSPostLOC BY
Group
/PLOT COMPARE VARIABLES
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING LISTWISE
/NOTOTAL.
BOXPLOT HISTOGRAM NPLOT
```

### \* RMM ANOVA

```
GLM NSS1 NSS2 PosttestBoth BY Group
/WSFACTOR=NSS 3 Polynomial
/MEASURE=NumberSense
/METHOD=SSTYPE(3)
/POSTHOC=Group(TUKEY GH)
/PLOT=PROFILE(NSS*Group)TYPE=LINE ERRORBAR=NO MEANREFERENCE=NO YAXIS=AUTO
/EMMEANS=TABLES(Group) COMPARE ADJ(BONFERRONI)
/PRINT=DESCRIPTIVE ETASQ OPOWER HOMOGENEITY
/CRITERIA=ALPHA(.05)
/DESIGN= Group.
```

```
UNIANOVA NSS1 BY Group
/METHOD=SSTYPE(3)
/INTERCEPT=INCLUDE
/POSTHOC=Group(TUKEY GH)
/EMMEANS=TABLES(Group) COMPARE ADJ
(BONFERRONI)
/PRINT ETASQ DESCRIPTIVE
HOMOGENEITY OPOWER
/CRITERIA=ALPHA(.05)
/DESIGN=Group.
```

```
(BONFERRONI)
/PRINT ETASQ DESCRIPTIVE HOMOGENEITY
OPOWER
/CRITERIA=ALPHA(.05)
/DESIGN=Group.
```

```
UNIANOVA NSS2 BY Group
/METHOD=SSTYPE(3)
/INTERCEPT=INCLUDE
/POSTHOC=Group(TUKEY)
/EMMEANS=TABLES(Group) COMPARE ADJ
```

```
UNIANOVA NSS3 BY Group
/METHOD=SSTYPE(3)
/INTERCEPT=INCLUDE
/POSTHOC=Group(TUKEY GH)
/EMMEANS=TABLES(Group) COMPARE ADJ
(LSD)
/PRINT ETASQ DESCRIPTIVE
HOMOGENEITY OPOWER
/CRITERIA=ALPHA(.05) /DESIGN=Gro
```

## Appendix F

### Syntax for Descriptive Statistics Intrinsic Motivation

Syntax for Descriptive Statistics Intrinsic Motivation: Reading

```
EXAMINE VARIABLES=YCAIMIR1 BY Group
/PLOT BOXPLOT HISTOGRAM NPLOT
/COMPARE VARIABLES
/PERCENTILES(5,10,25,50,75,90,95) HAVE
RAGE
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING LISTWISE
/NOTOTAL.
```

```
EXAMINE VARIABLES=YCAIMIR2 BY Group
/PLOT BOXPLOT HISTOGRAM NPLOT
/COMPARE VARIABLES
/PERCENTILES(5,10,25,50,75,90,95) HAVE
RAGE
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING LISTWISE
/NOTOTAL.
```

Syntax for Descriptive Statistics Intrinsic Motivation: Mathematics

```
EXAMINE VARIABLES=YCAIMIM1 BY Group
/PLOT BOXPLOT HISTOGRAM NPLOT
/COMPARE VARIABLES
/PERCENTILES(5,10,25,50,75,90,95) HAVE
RAGE
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING LISTWISE
/NOTOTA
```

```
EXAMINE VARIABLES=YCAIMIM2 BY Group
/PLOT BOXPLOT HISTOGRAM NPLOT
/COMPARE VARIABLES
/PERCENTILES(5,10,25,50,75,90,95) HAVE
RAGE
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING LISTWISE
/NOTOTAL.
```

Syntax for Nonparametric Tests: Independent Samples: Reading Motivation

```
NPTESTS
/INDEPENDENT TEST (YCAIMIR1 YCAIMIR2) GROUP (Group)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```

Syntax for Nonparametric Tests: Independent Samples: Math Motivation

```
NPTESTS
/INDEPENDENT TEST (YCAIMIM1 YCAIMIM2) GROUP (Group)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```

Syntax for Nonparametric Tests: Related Samples: Reading Motivation

```
NPTESTS
/RELATED TEST(YCAIMIR1 YCAIMR2)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95
```

\*Nonparametric Tests: Related Samples: Reading Motivation

```
NPTESTS
/RELATED TEST(YCAIMIM1 YCAIMR2)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```

# Appendix G

## Syntax for Descriptive Statistics for the Preschool Academic Mathematical Language

```
EXAMINE VARIABLES=PALM1 PALM2 PALM3 BY Group
/PLOT BOXPLOT HISTOGRAM NPLOT
/COMPARE GROUPS
/PERCENTILES(5,10,25,50,75,90,95) HAVERAGE
/STATISTICS DESCRIPTIVES EXTREME
/INTERVAL 95
/MISSING REPORT
/NOTOTAL.
```

### Syntax for Nonparametric Tests: Independent Samples

```
NPTESTS
/INDEPENDENT TEST (PALM1 PALM2) GROUP (Group)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```

```
NPTESTS
/INDEPENDENT TEST (PALM2 PALM3) GROUP (Group)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```

### Syntax for Nonparametric Tests: Paired Samples

```
NPTESTS
/RELATED TEST(PALM1 PALM2)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```

```
NPTESTS
/RELATED TEST(PALM2 PALM3)
/MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
/CRITERIA ALPHA=0.05 CILEVEL=95.
```