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Measuring Up for Big School:

A Role for Cognitive Development

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Abstract

For over 30 years, contention has surrounded the issue of preschool children's readiness for formal schooling. A Piagetian view is that the presence and use of particular operatory structures indicative of the concrete operational stage of cognitive development are necessary for a child to achieve successful learning outcomes in the new formal education environment of primary school. In any case, the non-standardised skills-based checklists utilised by many preschool teachers to infer children's levels of readiness for year one seem ineffectual as the debate regarding children's school readiness persists.

This paper reports on the findings from a research project in which forty-two preschool children were administered a Piagetian conservation of number task as outlined in the work of Piaget and Szeminska *The child's conception of number* (1941/1952) using the Genevan *méthode clinique.* Participants were also routinely assessed by their teachers using the preschool's Key Indicators of Readiness for Year One (KIRYO) Checklist and, in addition, then judged qualitatively on their preschool and early year one performance by the respective teachers. Children's performances on each of the above-mentioned indicators were scored quantitatively using detailed performance criteria derived explicitly from each item's source. Rasch analysis using the Partial Credit Model indicated that success on the conservation task was more closely aligned with children's success in year one than was mastery of the KIRYO Checklist indicators. The implications for professional discussion and decision-making, as well as insights for teachers of early childhood sectors are canvassed.

Introduction

Discussions of the transition from 'preschool' (the umbrella term used in this article to refer to all prior-to-formal-schooling settings) to primary school year one often involve the idea of children's school readiness. Given that most preschool settings implement readiness screening of some kind, early childhood educators consider readiness routinely as they plan learning experiences, evaluate progress, and make qualitative judgements about children's educational needs.

In formulating a readiness judgement preschool teachers often use skills-based, teacher-developed readiness checklists or reports. The Key Indicators of Readiness for Year One (KIRYO) Checklist used in this study was designed by the teachers of the preschool children and included indicators derived from key texts in the early childhood education field. In addition to a checklist, teachers often consider children's social and emotional behaviour, development of fine and gross motor skills, and willingness to 'have a go'. It seems that preschool teachers, keen to see their excited little charges progress to year one, are often reluctant to retain a possibly *unready* child in preschool for another year.

On the other hand, year one teachers are faced with the task of trying to bring a new intake of children to appropriate performance levels in year one curriculum areas such as Mathematics, English, and the like. Hence, children's curriculum content comprehension, intellectual maturity, and abilities to adhere to class rules and routines appear to be of much more of an interest to year one teachers. To be sure, the transition from the flexible, child-centred and play-based programs of preschool to the more rigid, curriculum-focused structure of most year one classrooms is a dramatic change for many young learners.

Indeed, parents rely on Government education policies and guidelines to ensure that their children 'hit the ground running' when they begin formal learning experiences. Current reforms, including the Queensland Government's introduction of a mandated Preparatory year of education (which include raising the legal school entry age by six months), are indications of the recognition of current inadequacies. The topic of school readiness is widely researched as children's *unreadiness* continues to be a problem for educators.

Somewhat surprisingly, however, is that the introduction of a 'Prep' year still fails to address what other research projects have unequivocally established - that age is not an accurate indicator of children's readiness for success in formal school settings (Bond, 2001). A number of small-scale research projects (e.g., Bond, 2003) have utilised successfully Rasch analysis and Piagetian theory to determine that children's levels of cognitive development say more about their abilities to achieve successful learning outcomes in formal school settings than their birth date does.

The Issue of School Readiness

It is well established that children's early learning experiences have both immediate and long-term effects on their development, educational achievement and general life prospects (Bredekamp & Copple, 1997; Briggs & Potter, 1999; Margetts, 2002; Maxwell & Clifford, 2004; Pianta & Kraft-Sayre, 1999, 2003; Potter & Briggs, 2003; Slavin, 1994; Timberley, McNaughton, Howie & Robinson, 2003; Wasik & Karweit, 1994; Whitebread, 1996). Children's capacities for success in early formal learning experiences are influenced by a myriad of elements such as parent/caregiver/teacher relationships, preschool to school continuity, levels of cognitive/physical/emotional/social development and more. Discussion of children beginning school often leads to debate about their readiness for school. Somewhat surprisingly, however, is the fact that most of the non-standardised locally-developed checklists used to assess school readiness are based typically on children's *motor* development (such as running, hopping, climbing, cutting and threading) – which does not always correlate with cognitive development (Baldwin, 1967; Wood, 1998). Indeed, cognitive development is best described as “a series of qualitative changes in cognitive functioning rather than merely as the quantitative increase in certain skills” (Baldwin, 1967, p. 86). Whilst it is beneficial for children to possess well-developed motor skills for use in their early learning experiences, it stands as evident that the concept of school readiness requires much more than that.

The literature concerning school readiness reveals the construct as problematic and difficult to define (Cuskelly & Detering, 2003; Lockwood & Fleet, 1999). Indicative of the conflict surrounding the issue, the term ‘school readiness’ is ambiguous - it describes the numerous different understandings of the constituents of the state of preparedness necessary for children to be successful in adjusting from less formal preschool settings to the more formal learning experiences presented in primary school. The nation-wide inconsistency in both the legal school starting ages, and the diversity of names given to describe the early education children receive before year one of primary school typifies the problem inherent in the progression from informal to formal learning throughout Australia. As already mentioned, in this study, the term ‘preschool’ represents all settings which children attend in the years before formal school (in addition to traditional preschool services).

Recent research on school readiness reveals remarkable imbalance – the majority of it focuses on adult perspectives and expectations of children’s school readiness and transitions (Broström, 2002; Dockett & Perry, 2001; 2004). Given the well-established claim that young children are inherently different from adults, it is surprising to observe that nearly all of the research produced to inform the early childhood sector is, indeed, *about* children with little or no empirical evidence from research *with* children.

In informing the school readiness debate, Piagetian theory would assert that successful adjustment to, and achievement in, early formal learning experiences is dependent on the attainment of certain intellectual structures indicative of the onset of the concrete operational stage of cognitive development (Baldwin, 1967). After the child achieves this higher-order stage of cognitive development, the mental processes of assimilation and accommodation more easily allow equilibrium between the child and the new formal school learning environment.

Piaget's theory of cognitive development

Piagetian theory describes children's intellectual development as progressing through an invariant sequence of age-related (*not* age-dependent) stages of thinking: sensorimotor (birth to approximately 2 years), preoperational (approximately 2 to 7 years), concrete operational (approximately 7 to 11 years), and formal operational (approximately 11 years onwards) (Ginsburg & Opper, 1988). Each cognitive developmental stage is characterized by the construction of different psychological structures, each new one of which enables a distinct and more effective type of interaction between the child and the environment (Ginsburg & Opper, 1988; Elkind, 1981, 1986).

Of particular relevance to early childhood educators is children's transition from Piaget's second stage, the preoperational stage, to the third, the concrete operational stage. Children inferred to be thinking in Piaget's preoperational stage of cognitive development are said to be ego-centric, experience difficulty taking into account others points of view, and use language in qualitatively different ways from those used by adults (Elkind, 1981; Smidt, 1998). Conversely, Piagetian theory asserts that when a child attains concrete operational structures, s/he is then more easily able to de-centre intellectually, take others points of view in to account, utilise more stable, systematic and logical thought processes, and achieve a more stable equilibrium between self and the environment (Ginsburg & Opper, 1988; Baldwin, 1980; Piaget, 1970; Smidt, 1998; Vernon, 1976; Wood, 1998).

It is this equilibrium – the progressive balancing of an organism with its environment – which presents as significant to the issue of children's school readiness. Adherents to Piagetian theory would view children's transition to year one as a "specific form of biological adaptation of a complex organism to a [new] complex environment" (Flavell, Miller & Miller, 2002, p. 5). Thus, children inferred to be thinking in the concrete operational stage of cognitive development (and hence, more intellectually developed) are said to be more likely to achieve successful learning outcomes in a formal Year One environment than those inferred to be in the preoperational stage of cognitive development (Bond, 2001).

The Study

The study reported here aimed to provide empirical insights into the issue of preschool children's school readiness by examining two different readiness indicators. Firstly, it verified the effectiveness of one preschool's Key Indicators of Readiness (KIRYO) Checklist as a current measure of readiness; and second, it established the role of cognitive development as an alternate indicator of readiness. For this purpose, a Piagetian conservation of number task was administered to each of the participating preschool children adhering to the *méthode clinique* procedures as explicated by Piaget (1961, 1970). Each participant's performance on individual KIRYO Checklist indicators was also recorded, together with qualitative judgements from both the preschool and successive year one teachers which provided data on participating children's actual levels of achievement in both settings.

Piaget's conservation of number task

Piaget's conservation of number task, administered using the Piagetian *méthode clinique*, is utilised specifically to infer the presence and use of concrete operational developmental structures. The conservation of number task is particularly apt for this project as number is the first physical concept a child conserves; furthermore, it relates directly to early concepts in the formal year one mathematics curriculum.

Conservation of number is demonstrated when a child understands that the equality of number of two sets of objects is independent of the appearance of the two sets when either is perceptually transformed (Baldwin, 1980; Ginsburg & Opper, 1988; Wallach, 1969). For example, a child can construct a second set (B) of objects from a first (A) using one-to-one correspondence, and can conserve that equality (A=B) although one set might be arranged to appear longer or shorter than the other. Both the child's conservation judgement and its operational justification are jointly important, as they reveal the thought processes that determine whether the child demonstrates conservation.

Method

Sample

Data were collected about 42 children from a preschool attached to a primary school in Queensland, Australia. The sample size, although comparatively small, was sufficient to reflect trends in the data, whilst remaining manageable in terms of time and resources constraints for the researcher. The sample was randomly selected from a cohort of 100 preschool children. There were 18 girls and 24 boys, with the children's ages ranging from 4 years and 11 months to 5 years and 11 months.

Data Collection

In the last three weeks of the preschool year, each of the participants was individually interviewed and administered the conservation of number task using the *méthode clinique* procedures as explicated by Piaget (1961, 1970). Each interview lasted between 10 and 15 minutes approximately, and was video-taped for later selective transcription and detailed analysis.

Each participant's preschool performance was routinely assessed by the preschool teacher according to the Key Indicators of Readiness for Year One (KIRYO) Checklist. As previously mentioned, the KIRYO Checklist used in this study was developed by the experienced teachers of the preschool children participating in this research project. It included indicators drawn from key texts in the early childhood education field, with a strong focus on the development of fine and gross motor skills (such as threading, cutting, running, jumping, hopping, etc.) . Children's levels of development of the various motor skills listed in the Checklist were categorized as either 'needs help' or 'satisfactory'.

Children who achieved only, or mostly, the ‘satisfactory’ category were deemed ready for year one. On the last day of the preschool year, each applicable checklist was photocopied, de-identified, and then coded to maintain children’s anonymity. No form of screening for children’s cognitive development levels was used by the preschool teachers.

To complement the above-described data, the preschool teachers were asked to provide qualitative judgements concerning each participants overall level of readiness for year one. Based on the teachers’ professional knowledge, each participant was inferred to be either, ‘not yet ready’, ‘nearly ready’, or ‘ready’ for probable success in year one learning experiences. These judgements were obtained on the last day of the preschool year, and recorded on a separate checklist for use by the researcher.

In the last week of semester one in the following school year, the successive Year One teachers were consulted to obtain data on the participants’ Year One achievement (i.e. about six months later). These teachers were asked to provide two qualitative judgements which were used, in conjunction with the three above-mentioned sources of data, to help determine the effectiveness of the KIRYO Checklist and conservation task as indicators of readiness. The first of two qualitative judgements elicited regarded each individual participant’s level of readiness for success in formal learning experiences as at the beginning of the year. This judgement, similar to the preschool teachers’ judgement, was based on the teachers’ professional knowledge of each participant whom they inferred to have been either, ‘not yet ready’, ‘nearly ready’, or ‘ready’ for probable success in year one learning experiences. The second judgement concerned each participant’s *actual* level of successful learning as at the end of semester one. This final qualitative judgement was based on participants’ actual performance in year one learning experiences which each was judged to be either, ‘not yet at level’, ‘almost at level’, or ‘at level’ in their achievement of relevant Key Learning Area (KLA) outcomes. The year one teachers had no knowledge of the preschool teachers’ qualitative judgements.

Data Analysis

To help determine the effectiveness of both the preschool's KIRYO Checklist and Piaget's conservation of number task as indicators of school readiness, a key model in modern test theory was utilised to analyse the raw data. The Rasch model is a quantitative, probabilistic measurement model that can convert raw data from the participants' KIRYO Checklist and conservation task performances into equal-interval scales suitable for comparison (Bond & Fox, 2001).

The nature of the data necessitated the use of the Partial Credit Model (PCM) (Wright & Stone, 1979) of the Rasch model family. Partial Credit scoring of the data required the construction of four sets of performance criteria: one each for the conservation task, preschool teachers' KIRYO checklist; the preschool teachers' qualitative judgements; and the year one teachers' qualitative judgements (see Appendix A). Responses for each item, for all four sets of criteria, were divided into hierarchically ordered levels of ability to which partial credit, for partial success, could be assigned. Items for this project where either dichotomous (two criteria: i.e. 'needs help'/'satisfactory') or polytomous (three criteria: i.e. 'not yet ready'/'nearly ready'/'ready'). Thus, scoring was completed using a progressive two-step (0, 1) or three-step (0, 1, 2) system as required by Rasch analysis and espoused by Bond and Fox (2001).

Each item score was then transcribed to an individual student data line within a larger data file inclusive of all children's performances (see Appendix B). Each data line consisted of the following types of data: the first two digits indicate the participant's identifying code; the following thirteen digits represent the participant's score on the thirteen conservation of number items; the following 29 digits represent the participant's score on the 29 KIRYO Checklist indicators; the following digit represents the score applicable to preschool teachers' qualitative judgement; and lastly, the final two digits represent the scores applicable to the year one teachers' two qualitative judgements (see example below).

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05 0001101210010 11111111111111111111111111111 2 22
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Each data line represents the transformation of qualitative data to quantitative data, which can then be subjected to Rasch analysis. Items for which there was no response were regarded as 'missing data', and the data line presented a blank at the applicable point. The Rasch family of models can utilise data files containing blanks as it will estimate ability and difficulty based on the available data. The statistical analysis was completed using Quest software (Adams & Khoo, 1992), a computer program developed from Rasch principles.

Results

The Rasch model's unidimensionality principle requires items under consideration to measure only one construct at a time: in this case, preschool children's readiness for probable success in year one. The efficacy of the Rasch analysis of the empirical data is determined largely by the degree of each item's fit to the construct being investigated. The Rasch model's item fit statistics were used to confirm that items did not breach this unidimensionality principle.

Fit Statistics

Item fit statistics are used to detect discrepancies between the Rasch model's theoretical expectations of item performance and the actual performance of that item according to the empirical data (Bond & Fox, 2001). Accepted values for the transformed *t* statistic of the infit and outfit mean square residuals range from -2 to +2, and are indicative of unidimensionality of the data (Bond & Fox, 2001; Drake, 1998).

Rasch analysis of the 45 test items as a data set revealed infit *t* values of up to 1.7, with a coexisting outfit *t* value of 1.5 for item K18. However, outfit *t* values peaked at 2.2 with a coexisting infit *t* value of .7 for item K14, with the next highest being item K20 with infit *t* and outfit *t* values of 1.5 and 2.0 respectively. Whilst these uppermost infit *t* and outfit *t* statistics are recorded for KIRYO Checklist items, the highest misfit estimate for item K14 sits just slightly outside the accepted fit statistic range, indicating satisfactory test unidimensionality. The fit statistics indicated that both the KIRYO Checklist and the conservation of number task were successful in investigating the single construct of school readiness.

Person-Item Maps

Rasch analysis output from Quest produced a person-item variable map – a logit scale with person and item performance estimates plotted along a single equal-interval continuum (see Figure 1). The logit scale is displayed down the middle of the map, with test items and person ability estimates located to the right and left of the scale, respectively. The value of each logit on the scale is equal (Bond & Fox, 2001), enabling inferences to made in regards to not only who is more able (or ready) than whom, but more specifically, *how much more* able or ready. Person and item locations on the scale are determined by the ability and difficulty estimates, respectively. A logit value of 0 is routinely set as the average, thus items of above average difficulty are plotted as positive, while items of below average difficulty are plotted as negative. Correspondingly, persons with ability above the average of the test items appear in the positive part of the scale, and persons with ability below that average appear in the negative part of the scale.

Each test item's location on the logit scale is determined by its estimated threshold. An item threshold is estimated at a point on the scale where a person of that estimated ability has a 50% probability of succeeding on that item. Items scored dichotomously (N1, N4, N5, N13, and all the

KIRYO Checklist items) have one item difficulty estimate plotted at the threshold where the probability of scoring either 0 or 1 is 50% (Bond & Fox, 2001). Thus for item N1, scored using criteria N1.0 and N1.1, the threshold between the two is 'N1' plotted at -2.04 logits separating the probability of scoring 0 and 1 on that item (when analysed as part of the whole set of 45 test items). Anything below that point relates to N1.0, and anything above, to N1.1. Items scored polytomously (i.e. N2, N3, N6, N7, N8, N9, N10, N11, N12, P1, O1, O2) have two difficulty thresholds plotted to separate the three response categories (0, 1, 2). For example, item N2, the criteria N2.0, N2.1, and N2.2 would be separated by the two plotted thresholds N2.1 and N2.2.

The person-item map produced from Rasch analysis of the whole data set is displayed in Figure 1 (item difficulty and person ability estimates for all 45 items). The logit scale covers a span of nearly 9 logits, ranging from about -3.0 logits to +6.0 logits vertically with item difficulty and person ability estimates plotted to the right and left respectively. When all data are considered collectively, item N9.2 (use of logical reasoning to consistently justify the invariance of the two sets in the number task) plotted at +5.30 logits, presents as the most difficult criterion to satisfy. Items K2, K3, K4, K13, K15, K16, K21, K23, K26, and K28 (indicators from the KIRYO Checklist), plotted at -2.46 logits, present as the criteria least difficult to satisfy.

Figure 1 displays person ability estimates as numerals on the left-hand side of the person-item map. Quest routinely represents each person ability location by an X, however, participant reference codes were inserted on the variable map to assist interpretation. Case 7, located at +5.84 logits, is clearly the most successful participant, whilst case 2, located at -1.93 logits, the least successful on these test items.

Figure 1

Item Difficulty and Person Ability Estimates for all 45 Items

```
          Most Successful                             Most Difficult
6.0                                 |
         7                          |
                                    |
                                    |
                                    |             N9.2
                                    |
 5.0                                |             N2.2 N11.2 N13
                                    |
                                    |             N12.2
                                    |
                                    |
         11                         |
 4.0     10                         |             N11.1
                                    |             N3.2
         37                         |             N10.2
         17   34                    |
         23                         |
         16 39 42                   |             N4 N6.2
 3.0     35                         |             N7.2
         6                          |
         8 14 21 24                 |
         26                         |                                          O2.2
         40 22 5 38 41              |                                   O1.2
         12 30 28 29                |             N6.1 N8.2 N10.1
 2.0     4 3 19                     |             N7.1
         1 32 31                    |             N12.1
                                    | K12
         9 13 27                    |
         15 20                      |             N8.1                             O2.1
         36                         |
                                    |
 1.0                                |             N5
         18                         |
                                    |                            P1.2
                                    |                                   O1.1
                                    |             N1
                                    |
                                    | K6 K9 K20   N9.1
 .0                                 |             N3.1
                                    | K19
         25                         |
                                    | K7 K18      N2.1
                                    |
                                    |
 -1.0    33                         | K5 K8 K10 K24
                                    |
                                    |
                                    | K1 K11 K17 K25
                                    |
         2                          |
 -2.0                               |                            P1.1
                                    |
                                    |
                                    | K2 K3 K4 K13 K14 K15 K16 K21 K23 K26 K28
                                    |
                                    |
  -3.0                              |
         Least Successful                         Least Difficult
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Note. Case colours indicate preschool teachers' qualitative judgement of: 'not yet ready', 'nearly ready' and 'ready'

Output Tables

Rasch analysis person-item maps present the relations between person ability and item difficulty only (Bond & Fox, 2001). Error estimates, fit statistics for items and persons and the corresponding reliabilities of these estimates are reported in the Quest output tables. Table 1 displays the item fit statistics (for all 45 items), and Table 2 presents the corresponding output summary; Table 3 displays the case fit statistics, and Table 4 presents the corresponding output summary.

Table 1

Rasch Analysis Results for all 45 Items

Item	Difficulty Estimate	Error Estimate	Infit *t*	Outfit *t*
N1	.49	.46	-.1	.4
N2.1	-.56	1.06	.8	.9
N2.2	4.99	.96	.8	.9
N3.1	-.13	.88	.7	.6
N3.2	3.84	.76	.7	.6
N4	3.16	.36	1.3	.7
N5	.86	.42	.2	-.2
N6.1	2.25	.63	-1.2	-.6
N6.2	3.28	.63	-1.2	-.6
N7.1	2.06	.63	-1.1	-.7
N7.2	3.08	.6	-1.1	-.7
N8.1	1.38	.63	-1.0	-.4
N8.2	2.20	.62	-1.0	-.4
N9.1	.06	.94	.4	.4
N9.2	5.30	1.06	.4	.4
N10.1	2.25	.63	-1.0	.4
N10.2	3.73	.70	-1.0	.4
N11.1	4.00	.94	.2	.7
N11.2	5.00	1.13	.2	.7
N12.1	1.88	.66	1.3	.7
N12.2	4.75	.86	1.3	.7
N13	4.95	.57	.6	.1
K1	-1.58	.83	-.9	-.4
K2	-2.46	1.11	.3	.3
K3	-2.46	1.11	.3	.3
K4	-2.46	1.11	.3	.3
K5	-1.01	.70	-.7	-.5
K6	.04	.52	.3	.6
K7	-.58	.62	-.3	.1
K8	-1.01	.70	-.7	-.5
K9	.04	.52	-.4	-.2
K10	-1.01	.70	-.4	0.0
K11	-1.58	.83	0.0	.3
K12	1.72	.36	0.0	-.2
K13	-2.46	1.11	-.4	.2
K14	-2.46	1.11	.7	2.2
K15	-2.46	1.11	.5	.5
K16	-2.46	1.11	.3	.3
K17	-1.58	.83	.8	.4
K18	-.58	.62	1.7	1.5
K19	-.25	.56	1.3	.7
K20	.04	.52	1.5	2.0
K21	-2.46	1.11	-.4	.2
K22	Item	has	perfect	score
K23	-2.46	1.11	-.4	.2
K24	-1.01	.70	-.2	-.2
K25	-1.58	.83	-.9	-.4
K26	-2.46	1.11	.5	.5
K27	Item	has	perfect	score
K28	-2.46	1.11	.5	.5
K29	Item	has	perfect	score
P1.1	-1.97	1.56	0.0	-.3
P1.2	.52	.97	0.0	-.3
O1.1	.63	.75	-.7	.1
O1.2	2.41	.62	-.7	.1
O2.1	1.47	.63	-.8	-.4
O2.2	2.49	.62	-.8	-.4

Note. The prefixes in the Item column represent items relating to the following: N = conservation of number task; K = KIRYO Checklist; P = Preschool teachers qualitative judgement; and O = Year One teachers qualitative judgement.

Table 2

Quest Output Summary of Item Estimates for All 45 Items

	Mean	SD	SD Variable	Reliability of Estimates
Summary of Item Estimates	0.00	2.21	2.04	.86
Fit Statistics				
Infit Mean Square	.98	.31		
Oufit Mean Square	.99	1.65		
Infit t	.06	.75		
Outfit t	.26	.63		
0 items with zero scores				
3 items with perfect scores				

The Rasch model's output tables present key information about the analysis of the whole data set. Table 2 presents output data pertinent to *item* estimates. This summary reveals that the mean of item estimates is located at 0 (by default), and that the standard deviation for item estimates is close to 2 (as displayed in Figure 1, the majority of indictors are located between +2 and -2 logits). The reliability of item difficulty estimates is reasonably high at 0.86 (on a scale of 0 to 1). The latter result refers to the ability of the test to define a hierarchy of indicators along the interval scale; "[t]he higher the number, the more confidence we can place in the replicability of item placement across other samples" (Bond & Fox, 2001, p. 46). The annotation at the bottom of the output advises that all but three items (with perfect-score status) were useful for discriminating ability amongst this sample.

Table 3

Rasch Analysis Results for All 42 Cases

Case	Difficulty Estimate	Error Estimate	Infit *t*	Outfit *t*
01	1.86	.44	-1.03	-.8
02	-1.93	.40	0.00	.26
03	2.02	.41	-1.37	-.88
04	2.02	.41	.82	.14
05	2.36	.41	.31	.07
06	2.89	.44	-.06	.03
07	5.84	.78	-.32	1.83
08	2.71	.43	-1.71	-.52
09	1.53	.40	-.49	.22
10	4.00	.51	-.77	.31
11	4.28	.54	.37	1.25
12	2.19	.41	-3.46	-1.22
13	1.53	.4	.11	-.41
14	2.71	.43	-.49	.56
15	1.37	.41	-2.23	-1.50
16	3.29	.46	-1.01	.07
17	3.51	.48	.35	.27
18	.71	.40	.19	.18
19	2.02	.41	-1.26	-.84
20	1.37	.41	-.55	.17
21	2.71	.43	-.68	-.50
22	2.36	.41	.02	-.45
23	3.33	.47	3.17	.63
24	2.71	.43	.40	-.16
25	-.40	.39	1.10	1.07
26	2.53	.42	.58	.64
27	1.53	.40	.71	1.11
28	2.19	.41	-.28	.05
29	2.19	.41	-.20	-.05
30	2.19	.41	.65	-.23
31	1.86	.41	.67	.24
32	1.86	.41	-3.44	-1.42
33	-1.00	.39	2.07	.52
34	3.51	.48	1.51	2.77
35	3.09	.45	1.27	.51
36	1.20	.41	.39	-.37
37	.75	.49	-.05	.27
38	2.36	.41	-1.43	-.36
39	3.29	.46	-1.20	-.17
40	2.36	.41	-1.68	-.85
41	2.36	.41	1.96	.91
42	3.29	.46	-.25	.03

Table 4

Quest Output Summary of Case Estimates for All 45 Items

	Mean	SD	SD Variable	Reliability of Estimates
Summary of Case Estimates	2.27	1.35	1.27	.89
Fit Statistics				
Infit Mean Square	.96	.44		
Oufit Mean Square	.99	1.98		
Infit t	-.19	1.31		
Outfit t	.08	.82		
0 cases with zero scores				
0 cases with perfect scores				

Table 4 presents the output table applicable to *case* estimates. The person ability estimate mean of +2.27 indicates that this sample on average found this test (i.e., all 45 items together) particularly easy, i.e the mean person performance is located more than one SD above the mean item difficulty. The mean person ability estimate (i.e. the group average) would need to be closer to 0 to indicate a well-matched test (Bond & Fox, 2001). The standard deviation of 1.35 reveals less spread of person measures than that of the item measures. The reliability estimate of 0.89 indicates that the person estimates reliability similar to that reported for items. This combined test is reasonably well targeted for this sample; however, some more difficult items are needed to raise the upper limit of the test. Furthermore, the least difficult items from the KIRYO Checklist would need to be revised to improve their contribution to the test.

Just as test items should satisfy the Rasch model's unidimensionality principle, so too should test cases, to help ensure that each and every aspect of the test contributes meaningfully to the measure of a single construct (Bond & Fox, 2001). The Rasch model produces transformed *t* statistics which can have either negative or positive values. Negative values are indicative of a highly predictable response pattern from a case, whereas positive values indicate more variation than expected from the Rasch model in a case's response pattern and are of greater importance to a developmentalist than are the former (Bond & Fox, 2001).

Transformed *t* statistics for cases 12, 15, and 32 indicate that their response patterns did not fit the Rasch model's expectations. Case 12, plotted at +2.19 logits, has an infit *t* value of -3.46 and an outfit *t* value of -1.22; case 15 (estimated ability +1.37 logits) produced an infit *t* of -2.23 and an outfit *t* of -1.50; case 32 (estimated ability +1.86 logits) reveals an infit *t* of -3.44 and an outfit *t* of -1.42. The above-mentioned cases were considered very predictable by the Rasch model as the "expectation is that there will be a zone of uncertainty or unpredictability around the person's level of ability" (Bond & Fox, 2001, p. 178) which was not apparent in these cases.

Conversely, case 23 presents as more haphazard than predicted by the Rasch model. With an estimated ability of +3.33 logits, case 23 has an infit *t* of +3.17 and an outfit *t* of +0.63 and, thus, is detected as 'erratic' in relation to the Rasch model's expectations. Review of the data reveals case 23 as a high performer in the conservation of number task data and one of 15 perfect-status achievers in the KIRYO Checklist data (see Figure 1). However, review of the Qualitative Judgements Chart reveals that he was inferred to be, by his Year One teacher, 'not yet ready' for probable success in year one learning experiences (as opposed to 'ready' as judged by the preschool teacher) and 'not yet at level' at the end of semester one.

Indeed, the year one teacher who inferred case 23 to be 'not yet ready' at the beginning of the year, and then acknowledged his level of successful achievement as 'not yet at level' despite his evident high abilities (see Figure 1) showed significant insight in her professional judgement. Review of this participant's conservation task and KIRYO Checklist performances presented him in the top 3% of the cohort. However, closer inspection of the Rasch model's fit statistics produced for cases (see

Table 4) revealed results in support of the year one teacher's judgements. The fit statistics for case 23 (infit mn sq=+2.79; oufit mn sq=+1.08; infit *t*= +3.17; outfit *t*=+.63) indicates a performance detected as erratic by the Rasch model's expectations. The misfit indicators suggest that in spite of the high overall score of case 23, some expected successes on easier items were in fact recorded as failures. This erratic performance could have something to do with English being this child's second language or the fact that he had just moved to Australia only a few months prior to the testing. The data file for case 23 reveals that the child failed (unexpectedly) on items N4, N12, O1 and O2. Although the overall score of the child implies readiness, the misfit suggests this score should not be taken at face value. It seems that the year one teacher has a view of the child's readiness which is sensitive qualitatively to the problem detected by Rasch analysis quantitatively.

Targeting

In addition to investigating a single underlying construct, Rasch measurement requires that tests under consideration also be suitably targetted to the sample to ensure that the relative difficulty of the items informs the construct under investigation. Thus, for this part of the study, the conservation of number task data and the KIRYO Checklist data were Rasch analysed *separately* to help infer which of the two was a more suitably targetted test.

To be sure, the conservation of number task was found to be the most precisely targetted and appropriate indicator of children's school readiness (see Figure 2). Displaying the most accurate mean person ability estimate mean of -.25 (SD=1.14) (close to 0), it stands as the best-matched test over and above that of the KIRYO Checklist (3.08; SD=1.26), or the three sources of data together (2.27; SD=1.35). Where only one child was completely unsuccessful on the conservation of number task (achieving a 0 score all on items), 15 "topped out" with perfect scores on the KIRYO Checklist. This demonstrates that the children found the readiness checklist very easy in comparison to the conservation task. While this might be expected in a criterion referenced rather than norm-referenced testing device, the results from year one teachers readiness judgements suggests that the readiness criteria adopted in the KIRYO Checklist are as inappropriately easy for this sample as evidenced by the foregoing comparison. Clearly, the results reveal that the conservation task is not only well targetted at the sample in order to inform the construct it investigates it is, by far, the best targetted for the sample of the three sources of readiness indicators. Conversely, the KIRYO Checklist is too easy and, thus, less well-matched to accurately enlighten the construct under investigation. Thus, the Rasch model revealed which of the conservation task or KIRYO Checklist corroborated a better targetted indicator of the underlying latent variable. Given the evidence, Piaget's conservation of number task stands to be the best targetted indicator of children's readiness for success in early formal learning experiences.

Figure 2

Targetting of Conservation of Number Task in Comparison to the KIRYO Checklist Indicators

Conservation of Number Task

```
 4.0              |
                  |
                  |
                  |
                  |
                  |
                  |
               X  |
 3.0              |
                  |
                  |
                  |      9.2
                  |     11.2
                  |      2.2
               X  |     13
                  |     12.2
 2.0              |
                  |
                  |
               X  |
                  |
                  |     11.1
              XX  |      3.2
                  |     10.2
 1.0              |
              XX  |
                  |      6.2
            XXXX  |
                  |      4   7.2
               X  |
                  |
  .0        XXXX  |
                  |
              XX  |
                  |
            XXXX  |      6.1  8.2  10.1
                  |      7.1
        XXXXXXXX  |
                  |     12.1
-1.0         XXX  |
                  |
                  |
            XXXX  |      8.1
                  |
                  |
              XX  |      5
                  |
-2.0              |      1
               X  |
                  |
                  |
               X  |      9.1
                  |      3.1
                  |
                  |
-3.0              |      2.1
```

Well-targetted test with even dispersion of person and item locations along the readiness continuum. All thresholds could be fitted to the display.

KIRYO Checklist Indicators

```
 4.0              |
                  |
                  |
                  |
                  |      12
                  |
                  |
                  |
         XXXXXXX  |
 3.0              |
                  |
                  |
                  |
              XX  |
                  |
                  |
                  |
               X  |
 2.0              |
                  |
               X  |
                  |
                  |
                  |   6  9  20
                  |
                  |  19
                  |
 1.0              |
                  |
                  |   7  18
               X  |
                  |
                  |
                  |   5   8  10  24
                  |
                  |
                  |
  .0           X  |
                  |   1  11  17  25
               X  |
                  |
                  |
                  |
                  |
                  |
                  |
-1.0              |
                  |   2   3   4  13  14
                  |
                  |
                  |
                  |
                  |
                  |
                  |
-2.0              |
```

Top-heavy person dispersion and limited item dispersion along the readiness continuum. Also, 15 cases excluded due to perfect-score status. Some thresholds could not be fitted to the display.

Inter-relationships

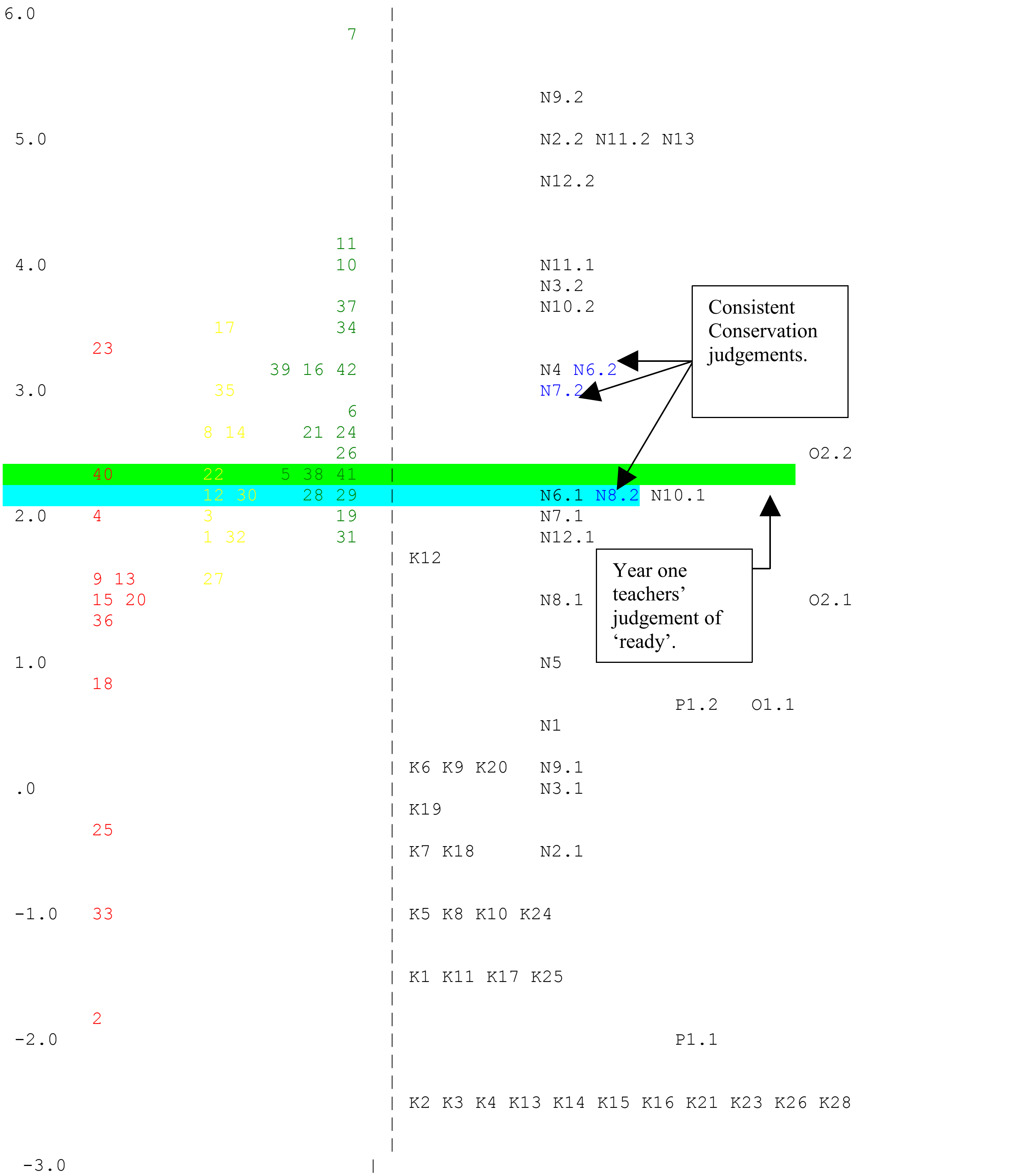
Rasch analysis of the data revealed remarkable inter-relationships between the year one teachers' qualitative judgements and Piaget's conservation of number task. It seems that the Piagetian viewpoint corresponds with the year one teachers' judgement of 'ready' for year one. The consistent conservation judgements (items N6.2, 7.2, and 8.2) (which are used in the conservation of number task to detect the presence and use of concrete operatory structures in a child's thinking) are located at this same 'cut-off' zone indicated by the shading in Figure 3. This empirical evidence suggests that an understanding of logical systems is, indeed, a likely contributor to the successful achievement of learning outcomes in early formal learning experiences; and, less equivocally, that Piaget's theory of knowledge is relevant to more completely understanding the nature of readiness for a successful transition from preschool to primary school.

It is evident in this small-scale investigation that two key elements invoked for understanding children's success in early formal learning experiences (the preschool and year one teachers' professional judgement of readiness) do not concur. The two logits difference between the preschool and year one teachers' judgements of 'ready,' together with the consensus of Piagetian theory and the year one teachers understanding of school readiness, is evidence of the need for further investigation into the understanding of readiness for success in year one that is held by these preschool teachers.

Indeed, the 29 indicators in the KIRYO Checklist based on social and motor skills do not present as a complete set of constituents of readiness for successful learning outcomes in year one. The empirical evidence herein reveals that a more comprehensive preschool readiness checklist would benefit from the inclusion of cognitive developmental indicators in the Piagetian tradition, not just the more rudimentary functional and mechanical skills such as K11 'gluing' and K13 'mouse control on computer'. It is commonly said that cognitive development is not necessarily associated with an increase in psychomotor skills.

Figure 3

Correlations between Conservation of Number Task and the Year One Teachers' Qualitative Judgement of 'ready'



Note. Year one teachers' qualitative judgements: 'not yet at level', 'nearly at level' and 'at level'. Year one teachers' qualitative judgement: 'ready' and cut-off point for 'ready'. Consistent conservation judgements and approximate cut-off point.

Whilst it would be helpful for year one teachers if all children were able to apply glue to paper neatly and possessed steadfast computer mouse skills, on this evidence, it is far more important for children to be ready for successful learning outcomes if they aim to avoid trouble in later schooling. It is widely accepted that success in early learning is a strong predictor of future successful schooling. Thus, the transition from preschool to year one is a crucial time for all young learners and they deserve the most appropriate of all tools on which judgements about their futures can be confidently made. The strong empirical evidence of a continuum of readiness presented in this small-scale study provides another example from the research at the School of Education at JCU of the functionality of the Piagetian framework for education sectors.

The results suggest that preschool teachers need to extend their ideas about what it means to be ready for successful learning outcomes in year one. Children's actual levels of successful achievement, as recorded half-way through year one, indicate that half the children were not ready in spite of the preschool teachers' professional judgement of 'ready'. Or perhaps, the case may be that the year one teachers were so concerned with syllabus content they continued to teach regardless of the lack of readiness of the children in the classes. Regardless, the lack of a shared understanding of the concept of readiness for year one amongst stakeholders is unacceptable. At best, it presents as a potentially serious discontinuity in children's learning experiences and teachers' expectations at an important transitional period.

The results of this study have highlighted several key areas where advances can be made. Foremost, teachers' judgements about children's progression to year one should be more developmentally sensitive and include an understanding of the Piagetian framework. In addition, the inclusion of several indicators based on children's understandings of logical systems, especially conservation of number concepts, on preschool readiness checklists could assist in inferring those children not yet ready for year one. Finally, all teachers should endeavour to be more responsive to the varying levels of cognitive development in children of similar age ranges in their class.

Indeed, the results for the persons and items under investigation in this study indicate that Piagetian theory and school readiness, together, are worthy of continued investigation.

Implications for Further Research

Foremost, the results of this research indicate the need for a similar study to be conducted with a larger sample of preschool children. Whilst the sample investigated was large enough to reveal trends in the data, another study including a greater spread of participant ability would be beneficial in informing the readiness construct, and confirming the value of Piaget's conservation of number task as an indicator of preschool children's school readiness.

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Appendix A

Conservation of Number Performance Criteria Derived from The Child's Conception of Number (Piaget, 1961) (from Drake, 1998, p. 45-46)

Item	**Stage I: Absence of conservation**	**Stage II: Intermediary reactions**	**Stage III: Necessary conservation**
N1	1.0 Incorrectly identifies the number of counters in the first set constructed.	1.1 Correctly identifies the number of counters in the first set constructed.	
N2	2.0 Global comparison: Does not construct equivalent second set. Reliance on perceptual cues.	2.1 Intuitive correspondence: Constructs equivalent second set using one to one correspondence: set constructed is identical to first.	2.2 Operational correspondence: Constructs equivalent sets using one to one correspondences, without making both sets look identical.
N3	3.0 Constructs equivalent sets only with assistance.	3.1 Carefully constructs sets, checking to ensure equivalence.	3.2 Constructs equivalent sets easily and quickly with confidence.
N4	4.0 Counts the second array to determine the number of counters within it.	4.1 Infers that the second array must be composed of the same number of counters as the first.	
N5	5.0 Does not infer the equivalence of the two arrays or infers the equivalence with assistance.	5.1 Infers the equivalence of the two arrays independently.	
N6	6.0 Judges that the equivalence of the two sets is changed if the appearance of one set is lengthened.	6.1 Sometimes correctly judges that the equivalence of the two sets remains the same if the appearance of one set is lengthened.	6.2 Consistently judges that the equivalence of the two sets remains the same if the appearance of one set is lengthened.
N7	7.0 Judges that the equivalence of the two sets is changed if the appearance of one set is condensed.	7.1 Sometimes correctly judges that the equivalence of the two sets remains the same if the appearance of one set is condensed.	7.2 Consistently judges that the equivalence of the two sets remains the same if the appearance of one set is condensed.
N8	8.0 Judges that the equivalence of the two sets is changed when faced with the Müller-Lyer effect.	8.1 Sometimes correctly judges that the equivalence of the two sets remains the same when faced with the Müller-Lyer effect.	8.2 Consistently judges that the equivalence of the two sets remains the same when faced with the Müller-Lyer effect.
N9	9.0 Makes no justifications, limited to judgements.	9.1 Uses illogical, inconsistent reasoning or counting to justify the variance or invariance of the two sets.	9.2 Uses logical reasoning to consistently justify the invariance of the two sets.
N10	10.0 Does not use identity argument to justify belief.	10.1 Uses identity argument illogically or inconsistently to justify the variance or invariance of the two sets.	10.2 Justifies true belief referring to the identity argument.
N11	11.0 Does not use reversibility argument to justify belief.	11.1 Uses reversibility argument illogically or inconsistently to justify the variance or invariance of the two sets.	11.2 Justifies true belief referring to the reversibility by inversion argument.
N12	12.0 Does not use compensation argument to justify belief.	12.1 Uses compensation argument illogically or inconsistently to justify the variance or invariance of the two sets.	12.2 Justifies true belief referring to the compensation argument.
N13		13.0 Does not refer to the necessary nature of conservation.	13.1 Refers to the necessary nature of conservation.

The 29 Key Indicators of Readiness for Year One (KIRYO) Checklist

Item	Key Indicators
K1	Balancing
K2	Running
K3	Jumping
K4	Climbing (scramble net)
K5	Hopping
K6	Skipping
K7	Kicking a ball
K8	Throwing / catching a ball
K9	Cutting
K10	Threading
K11	Gluing
K12	Pencil grip
K13	Mouse control on computer
K14	Expresses needs, feelings & ideas
K15	Comprehends messages spoken or visual
K16	Makes independent choices
K17	Persists with tasks copes with failure
K18	Mixes well with other children
K19	Understands the purpose of group rules and complies
K20	Shares, takes, turns, negotiates roles and resolves conflicts
K21	Sorts and matches objects by colour
K22	Names and matches basic colours
K23	Copies basic pattern eg. 2 colour pattern
K24	Drawing ability
K25	Completes a 9 piece puzzle using a variety of strategies
K26	Gives simple descriptions of past events
K27	Uses own grammar style, which is approximation of adult grammar
K28	Is beginning to develop awareness of listener needs and provides feedback on information when introducing a new topic
K29	Shows an interest in explanations of how and why

Preschool Teachers' Qualitative Judgements about Student Progression to Year One

Item	Stage I:	Stage II:	Stage III:
P1	30.0 "Not yet ready" for probable success in year one	30.1 "Nearly ready" for probable success in year one	30.2 "Ready" for probable success in year one

Year One Teachers' Qualitative Judgements about Student Progression to Year ONE

Item	Stage I	Stage II	Stage III
O1	31.0 "Not yet ready" for probable success in year one	31.1 "Nearly ready" for probable success in year one	31.2 "Ready" for probable success in year one
O2	32.0 "Not yet at level" in achievement of year one KLA outcomes	32.1 "Nearly at level" in achievement of year one KLA outcomes	32.2 "At level" in achievement of year one KLA outcomes

Appendix B

Data File of Participants' Scores

```
01 1110110000000 11111111111111111111111111111 2 21
02 000 000000000 01110000000001111111010001111 0 00
03 1111100011010 11111111111011111111111111111 2 11
04 1221100010010 11111111111111111101111111111 2 10
05 0001101210010 11111111111111111111111111111 2 22
06 1110122210000 11111111111111111111111111111 1 22
07 1221122212220 11111111111111111111111111111 2 22
08 1121111110010 11111111111111111111111111111 2 11
09 1110011110010 11111111111111110110111111111 1 10
10 1120122211020 11111111111111111111111111111 2 22
11 1111122222120 11111111111111111110111111111 2 12
12 1110101110010 11111111111111111111111111111 2 11
13 1000111111010 11111111111011111111111111111 1 00
14 1220111211010 11111111111111111100111111111 2 11
15 1110000010010 11111111111011111111111111111 2 10
16 1110111211111 11111111111011111111111111111 2 22
17 1010122212020 11111111111111111111111111111 2 21
18 1111100010010 11110000111011111111111111111 1 00
19 1110000110010 11111111111011111111111111111 2 22
20 1110000010110 11111111111111111011111111111 1 10
21 1111100210010 11111111111111111111111111111 2 22
22 1121100010010 11111111111111111111111111111 2 21
23 111012222220  11111111111111111111111111111 2 00
24 1111112200000 11111111111111111111111111111 2 12
25 0100000111000 11111111011011010100111010101 1 00
26 1211100211010 11111001111011111111111111111 2 22
27 1120100010110 11111111010111111111111011111 1 11
28 0110100211010 11111111111011111011111111111 2 22
29 1110000111110 11111111011011111111111111111 2 22
30 1110022200000 11111111111011111111111111111 2 11
31 0110011200000 11111111101011111111111111111 2 22
32 1110100110010 11111111111011111111111111111 2 11
33 0110100000000 00000000001011101111111101111 2 00
34 0111122222001 11111111111110111011111111111 2 22
35 1121100212011 11111011111111111111111111111 2 21
36 0100011111000 11111111111111111100111111111 2 00
37 1110122212001 11111111111111111111111111111 2 22
38 1110101211000 11111011111111111111111111111 2 12
39 1110122211000 11111111111111111111111111111 2 22
40 1110111211000 11111111111111111111111111111 2 10
41 1121112011000 11111111011111111000111111111 2 22
42 1110122212000 11111111111011111111111111111 2 22
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