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University of Connecticut
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Academic and Practical Intelligence

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The National Research Center on the Gifted and Talented (NRC/GT) is funded under the Jacob K. Javits Gifted and Talented Students Education Act, Institute of Education Sciences, United States Department of Education.

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ABSTRACT

This monograph describes interventions in a Native Alaska setting. The goal of the first study was to provide a further test of the hypothesis that academic and practical intelligence may be, from an individual-differences standpoint, largely distinct constructs. The goal of the second study was to examine the efficacy of culturally-based triarchic teaching in comparison with conventional teaching of a geometry unit. The research represented a first attempt to apply triarchic teaching to a mathematics curriculum, as well as a first attempt to apply such teaching using materials adapted to a cultural setting different from that of mainstream U.S. culture, Yup'ik Eskimos in southwest Alaska.

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EXECUTIVE SUMMARY

This monograph describes interventions in a Native Alaska setting. The goal of the first study was to provide a further test of the hypothesis deriving from the triarchic theory of successful intelligence (Sternberg, 1985a, 1997; Sternberg et al., 2000) that academic and practical intelligence may be, from an individual-differences standpoint, largely distinct constructs. Continuing our attempt to survey various unindustrialized cultures (i.e., different from those where the concept of intelligence originated) for the distinction between these two types of intelligence, in the present study we conduct research in the rural and relatively urban settlements of Alaska Natives[1], Yup'ik people. The main objective of this study was to explain the ratings on Yup'ik-valued traits in the studied adolescents by their performance indicators on tests of analytical and practical intelligence. Once again, our argument is that both kinds of intelligence can be important for predicting these traits of interest. Moreover, designing the study, we expected to see higher predictive power of the everyday life knowledge in rural communities. We found that children in the urban community outperformed children in the rural community on the test of crystallized intelligence; children in the rural community, however, outperformed children in the urban community on the test of practical intelligence. We also found that a measure of practical intelligence assessing tacit knowledge provided prediction of rated practical skills that was complementary and, in certain instances, incremental to the prediction provided by conventional measures of fluid and crystallized intelligence.

The goal of the second study was to examine the efficacy of culturally-based triarchic teaching in comparison with conventional teaching of a geometry unit. The research represented a first attempt to apply triarchic teaching to a mathematics curriculum, as well as a first attempt to apply such teaching using materials adapted to a cultural setting different from that of mainstream U.S. culture, Yup'ik Eskimos in

[1] The term Alaska Native is used in reference to Alaska's original inhabitants. Alaska Natives include three groups—Aleut, Eskimo, and Indian groups; the groups differ in terms of their ethnic origin, language, and culture.

southwest Alaska. The results showed superior instructional outcomes for all dependent variables, including assessments of memory-based as well as analytically-, creatively-, and practically based achievement. Our data provide an extension of past data showing that triarchic instruction is superior to conventional instruction across a variety of school subject-matters, participant age levels (primary and secondary), and participant socioeconomic levels. This demonstration shows that teaching analytically, creatively, and practically in a cultural setting rather remote from that of the mainstream United States can make a difference to school achievement, at least if the teaching is adapted to the cultural setting of the individuals, in this case, Yup'ik Eskimos in southwest Alaska.

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Intervention Study I—Academic and Practical Intelligence: A Case Study of the Yup'ik in Alaska

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Academic and Practical Intelligence: A Brief Review of the Literature

Although psychologists and laypeople often think of intelligence as a unitary entity, various aspects of intelligence (e.g., intelligence demonstrated in a classroom and intelligence demonstrated in everyday life) may be somewhat distinct. One of the earliest psychologists to make this point was an experimental psychologist, Edward Thorndike (1924), who argued that social intelligence is distinct from the kind of intelligence measured by conventional intelligence tests. Many others subsequently have made this claim as well about social and practical intelligences (see reviews in Kihlstrom & Cantor, 2000; Sternberg et al, 2000; R. Wagner, 2000). A related claim was made by a well-known psychometrician, J. P. Guilford (1967), who separated behavioral content from more typical kinds of test-like content in his theory of the structure of intellect. More recently, Howard Gardner (1983, 1999) has argued that interpersonal and intrapersonal intelligences are distinct from the more academic ones (e.g., linguistic and logical-mathematical). Similarly (Mayer, Caruso, & Salovey, 1999; Mayer, Salovey, & Caruso, 2000; Salovey & Mayer, 1990; see also Goleman, 1995) further stressed the multidimensionality of intelligence, pointing out the separateness of emotional intelligence.

Speaking generally, Neisser (1976) stated that the conventional wisdom accurately reflects two different kinds of intelligence, academic and practical. Implicit theories of intelligence, in the United States (Sternberg, 1985a; Sternberg, Conway, Ketron, & Bernstein, 1981) and elsewhere (Grigorenko et al, 2001; Sternberg & Kaufman, 1998; Yang & Sternberg, 1997), also suggest some separation of academic and practical aspects of intelligence. Although specifics of definitions of academic and practical intelligence vary between studies and cultures, the thrust of these notions remains the same: the concept of academic (analytical) intelligence is used to signify the person's ability to solve problems in academic (classroom-like) settings, whereas the concept of practical intelligence is used to signify the person's ability to solve problems in everyday settings (practical life problems). For children, aspects of classroom-like settings may invoke practical intelligence. For example, knowing the information for a test invokes largely academic intelligence, but knowing how to study for the test invokes a great deal of practical intelligence.

The psychological theory underlying the present research makes a similar claim, namely, for a distinction between analytical intelligence (or what Neisser refers to as "academic intelligence") and practical intelligence (Sternberg, 1985b, 1988, 1997, 1999). According to Sternberg's triarchic theory of successful intelligence, the basic information-processing components underlying abstract analytical and applied practical intelligence are the same (e.g., defining problems, formulating strategies, inferring relations, and so on). But differences in tasks and situations requiring the two kinds of intelligence, and hence in the concrete contexts in which they are used, can render the correlations between scores on tests of the two kinds of intelligence positive, trivial or, in principle, negative (see Sternberg et al., 2000; Sternberg, Nokes et al., 2001). From the point of view of individual differences, people who well apply a set of processes in one context may not be those who well apply them in another context.

The issue is not over whether analytical (academic) intelligence matters at all. We believe there is solid evidence that the kind of analytical intelligence measured by conventional kinds of intelligence tests predicts performance, at least to some degree, in a variety of situations (see Barrett & Depinet, 1991; Carroll, 1993; Gottfredson, 1997; Herrnstein & Murray, 1994; Hunter & Hunter, 1984; Jensen, 1998; Neisser et al., 1996; Schmidt & Hunter, 1981; Sternberg, Grigorenko, & Bundy, 2001; Wigdor & Garner, 1982; see also essays in Sternberg, 2000). Hence, we would not want to test for everyday life intelligence (i.e., practical intelligence) *rather than* for conventional intelligence (i.e., academic intelligence; McClelland, 1973); instead, we might want to test for the practical form of intelligence *in addition* to the particularly academic form of intelligence, because both might predict various kinds of performance relatively independently. Our argument is that both kinds of intelligence can be important in a variety of situations.

A growing body of empirical data suggests that there indeed may be a true psychological distinction between academic and practical intelligence (see Sternberg et al., 2000; R. Wagner, 2000). If there is, then conventional ability tests standing alone may tell us substantially less than we ideally would want to know about people's performance in the practical situations they encounter in their daily lives. We cite some of this evidence here, although more nearly complete reviews can be found in Sternberg et al. (2000), Sternberg, Wagner, Williams, and Horvath (1995), and in R. Wagner (2000).

Denney and Palmer (1981) compared the performance of adults of diverse ages on two types of reasoning problems: a traditional cognitive measure and a problem-solving task involving real-life situations. The most interesting result of this study for our present purpose was that performance on the traditional cognitive (academic) measure decreased linearly after age 20 whereas performance on the practical problem-solving task increased to a peak in the 40- and 50-year old age groups, and only then declined. Practical intelligence thus showed a developmental function over age more similar to crystallized than to fluid intelligence (Horn, 1994; Horn & Cattell, 1966).

A similar result was found by Cornelius and Caspi (1987), who explicitly looked at measures of fluid, crystallized, and practical intelligence. (The practical measures involved tasks such as dealing with a landlord who would not make repairs, getting a friend to visit one more often, and what to do when one has been passed over for promotion.) Fluid abilities showed increases from about age 20 or 30 to age 50 and then declined. Crystallized and practical abilities increased until about age 70 before declining. However, the measures of practical abilities showed only modest correlations with both the fluid and crystallized abilities measures, suggesting that the practical measures were assessing a distinct construct.

Scribner (1984) investigated strategies used by milk-processing plant workers to fill orders. She found that rather than employing typical mathematical algorithms learned in the classroom, experienced assemblers used complex strategies for combining partially filled cases in a manner that minimized the number of moves required to complete an order. Although the assemblers were the least educated workers in the plant, they were able to calculate in their heads quantities expressed in different base number systems, and they routinely outperformed the more highly educated white-collar workers who substituted when assemblers were absent. The order-filling performance of the assemblers was unrelated to measures of school performance, including intelligence-test scores, arithmetic-test scores, and grades.

Another series of studies of everyday mathematics involved shoppers in California grocery stores who sought to buy at the cheapest cost when the same products were available in different-sized containers. These studies were performed before cost-per-unit quantity information was routinely posted. Lave, Murtaugh, and de la Roche (1984) found that effective shoppers used mental shortcuts to get an easily obtained answer accurate (although not always completely accurate) enough to determine which size to buy. But when these same individuals were given a mental-arithmetic test that required them to do much the same thing in a paper-and-pencil format, there was no relation between their ability to do the paper-and-pencil problems and their ability to pick the best values in the supermarket.

Nuñes and her colleagues (1994; Carraher, Carraher, & Schliemann, 1985) have studied the performance of Brazilian street children in mathematical reasoning tasks (see also Ceci, 1996; Ceci & Roazzi, 1994). They found, similarly to Lave and her colleagues, that the same children who were able to solve arithmetical problems in the setting where they actually needed to use these operations in their daily lives were often unable to solve comparable problems presented to them abstractly in paper-and-pencil format. A similar finding emanates from the research of D. Wagner (1978), who showed that whereas Western adults did better than Moroccan rug dealers on a fairly abstract memory test, the rug dealers did better on tests of their memory for patterns on Oriental rugs.

In our own research (reviewed in Sternberg et al., 2000; Sternberg, Wagner, & Okagaki, 1993; Sternberg et al., 1995), we have investigated practical knowledge as it applies in a variety of occupations, including management, sales, teaching, and military leadership. We have devised tests of an aspect of practical intelligence, which is what one needs to know to succeed in a context of his or her everyday life. Specifically, we have constructed scenarios of the kinds people encounter in their daily lives and in which the people face on-the-job problems that they need to solve. Participants in our studies then are typically presented with a variety of options for solving the problems. They are asked to rate the quality of each of the options, typically on a 1-9 scale. Responses are scored against those of experts. The closer the participant's profile is to the mean profile of the experts, the better the score on the test.

In a series of about a dozen studies extending over close to 15 years (see Sternberg et al., 2000), we have made a number of observations. Most relevant here are the observations that (a) practical intelligence measures tend to correlate significantly with each other (Sternberg et al., 2000); (b) they correlate variably with measures of academic intelligence—sometimes positively, often not at all, and sometimes negatively (Sternberg et al., 2001); (c) they tend to predict criteria of job success about as well as or at times even better than do indicators of academic intelligence, IQ (Sternberg et al., 2000); and (d) they predict job performance significantly, even when variables including IQ, personality, and styles of thinking are placed first into a hierarchical regression model (Sternberg et al., 2000). Here we present only a number of studies, especially relevant to this monograph.

Sternberg et al. (2001) tested in rural adolescents of western Kenya the notion that academic and practical intelligence are separable and relatively distinct constructs. The main dependent variable of interest was the adolescents' scores on a test of their knowledge for natural herbal medicines used to fight illnesses. This kind of knowledge is viewed by the villagers as important in adaptation to their environment, which is understandable given that the overwhelming majority of the children have, at a given time, parasitic infections that can interfere with their daily functioning. In other words, it is type of knowledge that is relevant to the villagers' everyday life. We found that scores on the assessments of practical intelligence correlated trivially or significantly negatively with conventional measures of academic intelligence and achievement, even after controlling for socioeconomic status. Such a result is probably most likely in a society, such as that of rural Kenya, where implicit theories of intelligence depart greatly from Western explicit theories of intelligence. Indeed, Kenyan implicit theories of intelligence stress everyday skills far more than they stress academic ones (Grigorenko et al., 2001). Moreover, it has been shown that implicit theories of intelligence can affect the way people go about doing tasks in their academic as well as everyday lives (Dweck, 1999).

In another study, Grigorenko and Sternberg (2001) studied a large group of Russian adults living in a provincial city. We used conventional measures of intelligence as indicators of analytical intelligence and vignettes depicting everyday life situations and self-ratings of behavior as indicators of practical intelligence. The indicators of analytical and practical intelligence were used to predict mental and physical health among the Russian adults. Mental health was measured by widely used paper-and-pencil tests of depression and anxiety and physical health was measured by self-report. The best predictor of mental and physical health was the practical intelligence measure. Analytical intelligence came second. Both contributed to prediction, however. Thus, we again concluded that theories of intelligence, to provide better prediction of success in life in a variety of domains (rather than in a single domain of school success), should encompass abilities important for everyday life as well as academic abilities.

Any one or even subset of these findings might be criticized for one or another reason. But taken together, with their different strengths and weaknesses, the body of evidence suggests that the conventional wisdom that academic and practical intelligence are largely separate constructs may genuinely best represent the data that are currently available. If this is the case, then the general factor sometimes identified as central to intelligence needs to be viewed in a different way from the way it is conventionally viewed.

Claims of a general factor of intelligence, dating back to Spearman (1904) and continuing on to the present day (e.g., Carroll, 1993; Jensen, 1998; see essays in Sternberg & Grigorenko, 2002) then take on a different cast. This cast is that the general factor, to the extent it exists, may characterize academic forms of intelligence quite well, but may not extend as well beyond them. Our goal is not to argue whether there "really" is a general factor in human intelligence, because from our point of view, the question easily degenerates into a semantic one. If one defines intelligence somewhat more narrowly (e.g., Jensen, 1998), a general factor usually appears. If one defines intelligence somewhat more broadly (e.g., Gardner, 1983, 1999; Sternberg, 1985b), then it does not appear, or at least not with the full generality typically ascribed to it.

Our goal in the present study was to provide a further test of the hypothesis deriving from the triarchic theory of successful intelligence (Sternberg, 1985b, 1997; Sternberg et al., 2000) that academic and practical intelligence may be, from an individual differences standpoint, largely distinct constructs. Continuing our attempt to survey various unindustrialized cultures (i.e., different from those where the concept of intelligence originated) for the distinction between these two types of intelligence, in the present study we conduct research in the rural and relatively urban settlements of Alaska Natives,[1] Yup'ik people. The main objective of this study was to explain the ratings on Yup'ik-valued traits in the studied adolescents by their performance indicators on tests of analytical and practical intelligence. Once again, our argument is that both kinds of intelligence can be important for predicting these traits of interest. Moreover, designing the study, we expected to see higher predictive power of the everyday life knowledge in rural communities.

Yup'ik Culture: A Brief Overview

The word "Yup'ik" means "real person" in the Yup'ik language. This language is still spoken among many of the Yup'ik people, who live primarily in the central and western portions of Alaska. They live mostly on flat, marshy, often frozen plains intersected by numerous bodies of water of the Yukon and the Kuskokwin Rivers, draining their waters through southwest Alaska westward into the Bering Sea. Yup'ik people constitute the largest group of Alaska's Native Americans [Eskimo—Inupiat (Inupiaq) and Yup'ik Inuit, Aleuts (Alutiq), and Indians (Athabaskans)].

Federal census data do not provide specific information on the number of Yup'ik people, because the data are broken down separately for Eskimos, Aleuts, and American Indians without differentiating between Yup'ik and Inupiat Eskimos, or among numerous subgroups of Alaskan Athabaskans. Thus, only approximate numbers are available (University of Alaska Fairbanks, n.d.). Specifically, the self-identified Eskimo population of Alaska in 1990 was 44, 401, of whom 48.6% (21,619) lived in Yup'ik areas and 28.5% lived in Inupiat areas. Approximately 17.1% of the Eskimo population lived in cities of Alaska (Anchorage and Fairbanks) and 5.7% lived in other Alaskan locations. Other sources indicate that the size of Yup'ik population is about 21,000 people (Alaska Native Language Center, 2001).

Today's Yup'ik people live in modern houses with electricity, oil, telephone, and satellite TV. However, a large part of the culture of these communities is subsistence fishing and hunting (although most people now supplement their meals with store-bought food), and the culture remains highly intertwined with the natural environment (Lipka, Mohatt, & the Ciulistet Group, 1998). Temperatures in Yup'ik country range greatly, from as low as -80 degrees F. in the winter to as high as 80 degrees F. in the summer (Fineup-Riordan, 1990). The ocean, rivers, and lakes are rich with fish; the tundra is rich with wild life. Villages are situated at large distances from each other. Thus, living in rural Alaska calls for a variety of adaptive skills. Children are taught from an early age survival skills that long ago became largely irrelevant for most people living in North America and Europe. Those Yup'ik children who fail to learn these survival skills, fail at their own potential peril.

Social life among the Yup'ik people centers around the extended family and the community. Many Yup'ik live in small isolated communities, where we have done most of our work (as well as other work; see Sternberg, Lipka, Newman, Wildfeuer, & Grigorenko, 2002). During winter, most of these villages can be reached from other parts of Alaska only by airplane, because they are separated from each other by vast, difficult to travel tundra. Some choose to travel by snow-go (snowmobile), although doing so requires an intimate knowledge of the terrain, as there are no marked roads and visibility can change quickly with the weather.

In the summer, ships can land in the communities that are situated near water. Many of the Yup'ik live on modest income (because the main source of income often is through commercial fishing and hunting, both of which are season dependent and vary greatly annually in yield), and governmental economic assistance is commonplace.

Village men and women teach survival skills as well as traditional crafts. Elders are relied upon for their wisdom, and elders speak from time to time at community centers to communicate this wisdom. Thus, elders are viewed and treated as the source of traditional Yup'ik knowledge. One of the central elements of preserving the traditional Eskimo culture relates to the presentation of the Yup'ik language. However, only about 71% of the population in the Yup'ik speaking areas speak the language. Yup'ik children and teenagers are faced with the difficult challenge of trying to negotiate two worlds—the more traditional world of the elders and the more modern world of outside. For example, children still grow up speaking Yup'ik as their first language in only 17 of 68 Yup'ik villages (Alaska Native Language Center, 2001). Yet, Alaska Native children, along with other American Indian students, under-perform in core academic subjects (e.g., National Center for Education Statistics [NCES], 2001).

As indicated above, the main objective of the study was to evaluate the predictive power of indicators of analytical intelligence (fluid and crystallized abilities) compare to that of indicators of practical intelligence while regressing both on ratings of Yup'ik qualities among adolescents (boys and girls) living in the relatively urban community (Dillingham) and the rural communities (all the other locations) of Southern Alaska.

Method

Participants

There were a total of 261 rated by adults or peers in the study: 69 in grade 9, 69 in grade 10, 45 in grade 11, 37 in grade 12; 41 adolescents did not indicate their grade. Of the adolescents in the study, 145 were females (74 from the rural and 71 from the semi-urban communities) and 116 were males (62 were from the rural and 54 were from the semi-urban communities). They were from seven different Alaskan rural communities: Akiachak (*N*=27), Akiak (*N*=21), Dillingham (*N*=125), Manokotak (*N*=17), New Stuyahok (*N*=22), Togiak (*N*=37), and Tuluksak (*N*=12). All of these communities are small rural, primarily Yup'ik villages, except Dillingham, which is relatively urban (by Alaskan standards), although not a major urban area (such as Anchorage, Fairbanks, or Juneau).

The rural communities were all traditional Eskimo villages with a fishing, hunting, and subsistence lifestyle. At the time of the study, the largest village we worked in, Togiak, had a population of approximately 750 individuals, and the smallest village, Akiak, had approximately 280 individuals. Self-reported available data suggest that the percentage of residents in these villages who are Native Alaskans is 90-95%. The majority of the children in the villages come to school with greater proficiency in Yup'ik than in English.

Dillingham is a town located at the extreme northern end of Nushagak Bay in northern Bristol Bay. The current population of Dillingham is about 2,500 people, of whom approximately 55.8% are Alaska Natives (Eskimo, Aleuts, and Indians). Dillingham is the economic, transportation, and public-service center for western Bristol Bay. The primary activities in Dillingham are fish processing, cold storage, and support of fishing industry. In Dillingham, although Yup'ik is spoken by adults in shops and homes, the level of proficiency among children and adolescents is low.

Materials

Independent variables. Independent variables were of two kinds—psychometric reference tests and our own measure, the Yup'ik Scale of Practical Intelligence (YSPI).

1. *Test of "g": Culture Fair, Scale 2, Form A*. This test (Cattell & Cattell, 1960) measures fluid abilities. The test consists exclusively of geometric-reasoning items. It has four subtests: series completions (12 items), classifications (14 items), matrix completions (12 items), and topology (8 items).

2. *Mill Hill Vocabulary Scale—Junior Multiple Choice, U.S. Edition (1985 Revision), Forms A and B*. Each form consists of 1 practice item and 32 multiple-choice synonyms items. This test measures crystallized abilities.

3. *Yup'ik Scale of Practical Intelligence (YSPI)*. This test, developed especially for this study, has 36 multiple-choice items. The test assesses the presence of knowledge relevant to the participants' performance in situations encountered in everyday life of Yup'ik people and, therefore, relevant to adaptation in the primarily rural environment in which most of them live. The test measures everyday life knowledge in various content areas including gathering and processing herbs and berries, fishing and fish preparation, knowledge of weather and indigenous tradition, and hunting. Tests of practical everyday knowledge can be more domain general or more domain specific, and more population general or population specific. This particular test was designed primarily to be domain specific and population specific.

The procedure for creating such a test is described in Sternberg et al. (2000). The test was created in collaboration between researchers and local residents (including one of the coauthors of this study), based on extensive interviews. Because the test is unfamiliar, we present here example items from the test for each content area. An asterisk (*) indicates the correct response.

a. *Herbs and Berries*

I can usually find the most *atsalugpiat* (cloudberries/salmonberries) in the:

a) grass far from the water.
b) hills that appear dry.

c) hills that appear green.
d) grass near a pond or marsh.*

b. *Fishing and Fish Preparation*

Julie likes to make *sulunaqs* (salted fish heads) for her family. *Sulunaqs* are made from:

a) trout.
b) pike.
c) king.*
d) tomcod.

c. *Knowledge of Weather*

When Eddie runs to collect the ptarmigan that he's just shot, he notices that its front pouch (balloon) is full of ptarmigan food. This is a sign that:

a) there's a storm on the way.*
b) winter is almost over.
c) it's hard to find food this season.
d) it hasn't snowed in a long time.

d. *Hunting*

Uncle Markus knows a lot about hunting wolverines. He is most likely to catch a wolverine when he sets his trap:

a) on a slanted tree.*
b) in the hollow of a dead tree.
c) far from any water.
d) near a frozen river.

Since there were a relatively small number of items (*N*=36), we constructed only 2 subscales of the YSPI—one indicating the knowledge of sea and river (e.g., fishing, fish preparation and preservation, weather in the sea—hereafter *Sea and River Knowledge*, 17 items) and the other indicating the knowledge of land (e.g., hunting, trapping, knowledge of herbs and berries and weather in tundra—hereafter *Land Knowledge*, 19 items).

Dependent variables. There were three major dependent variables pertaining to practical skills valued by Yup'ik people. The questions through which these dependent variables were operationalized were formulated after conducting 30 interviews with the elders, adults, and adolescents in the community, nominated by the community members as "good Yup'ik people." During the interviews, we asked the interviewees to identify qualities of the people that are valued the most by the community members. This qualitative investigation resulted in the formulation of the following questions:

1. Of the adolescents on your list, who is the most *umyuartuli* (a good thinker, one who comes up with novel solutions to problems and uses the mind to survive)?
2. Which of the adolescents on your list is the most *qigcikluki tegganret* (respectful of elders)?
3. Who is the best
   a. *picul'i* (great hunter)? [for boys only]
   b. *cayunailnguq* (seamstress, cook, house-keeper)? [for girls]

These questions were asked both of adults (teachers and community leaders) and of peers of the adolescents. The methodology for collecting and analyzing these ratings was rather complex, because not all raters knew all adolescents to be rated. This procedure is described fully in Grigorenko et al. (2001). In brief, we used standardized units of comparison by dividing the sample of adolescents into triples[2] and implemented a formal strategy for quantifying individual differences.

The scoring procedure worked as follows. The raw data were in the form of combinations of "ones" and "zeros." The chosen adolescents were assigned a "one" (1), and the adolescents who failed to be chosen were assigned a "zero" (0). For example, consider a triple consisting of adolescents A, B, and C (triple 1). Suppose that Rater 1 selected Adolescent A as the best *umyuartuli* among the three adolescents he or she compared. Then, for this comparison, the data set would have a record of 1 for Adolescent A, and records of 0 for Adolescents B and C. Now, suppose that Rater 2 chose to compare adolescents in a triple consisting of participants A, B, and D (triple 2). Assume that Rater 2 also selected Adolescent A as the best *umyuartuli*. Then the corresponding subset of the full data set has the following information:

	Adolescent	Triple	Score
	A	1	1
Rater 1	B	1	0
	C	1	0
	A	2	1
Rater 2	B	2	0
	D	2	0

This information can be recoded so that every occurrence of a 1 reflects a probability of being chosen as best in a given triple. Thus, for the triple 1, where rows dominate columns,

	A	B	C
A	.	1	1
B	0	.	.
C	0	.	.

and for triple 2,

	A	B	D
A	.	1	1
B	0	.	.
D	0	.	.

In other words, given that a triple of a given structure (A, B, and C) was evaluated by a given rater (e.g., Rater 1), the probability of Adolescent A being chosen was 1, whereas for Adolescents B and C it was 0. There was no information about the probability of Adolescent B being chosen over Adolescent C (or vice versa); therefore, these points in the table were recoded as missing data points. Similarly, when Adolescent A was evaluated in the A-B-D triple, he was also chosen over Adolescents B and C; there was no information about the probability of Adolescent B being chosen over Adolescent D (or vice versa).

At the next stage, the data were converted into the format of pairwise comparisons (i.e., A versus B, A versus C, B versus C, A versus D, B versus D, and D versus C). The probabilities of a given adolescent being chosen in a given pair were summed over the total sample and then averaged by the number of comparisons of a given pair (in the example above, the pair A versus B was compared twice, in the triple 1 (A, B, and C) and in the triple 2 (A, B, and D); therefore, the probability of A being chosen over B is [1+1]/2=1). The number of comparisons for each pair was recorded as a separate variable. Thus, the data have a two-way structure: adolescent and comparison adolescent. There are, however, many missing data points because not every adolescent is paired with every other adolescent. Yet, multiple comparisons provide enough information to elicit adolescent-based parameter estimates. Therefore, the recoded data reflecting the probability that a given adolescent would be chosen over another adolescent in a given pair when a certain number of comparisons were carried out were subjected to analysis of variance. In this analysis we obtained parameter estimates indicating the variability in ratings attributable to individual differences between adolescents on a given trait; these parameter estimates were saved and then became dependent variables in subsequent analyses. The internal properties of this analysis were evaluated by means of components-of-variance analysis (specifically, the variance components due to adolescent, comparison adolescent, and error were estimated).

The ratings were generated separately for peers and adults. To reduce the dimensionality of the indicators and to minimize measurement error, we applied principal-component analyses to matching ratings. The factor scores from the first principal components were saved and used in subsequent analyses. Specifically, the ratings of adults and peers shared 60% of the variance for Question 1 (hereafter the factor score on the first principal component is referred as an indicator of *Thinking Skills*); 65% for Question 2 (hereafter referred as an indicator of *Respect for Elders*); 73% for Question 3 for boys (hereafter referred as an indicator of *Hunting Skills*); and 68% for Question 3 for girls (hereafter referred as an indicator of *Household Skills*).

Design

All participants were expected to receive all measures. The design was thus planned to be fully within-subjects. However, not all raters rated all individuals (and, indeed, they could not because they were from different communities), so the ratings matrix was incomplete (see Grigorenko et al., 2001). Moreover, not all adolescents who were rated (dependent variable) were available to be tested with the psychometric measures used in the study (or vice versa). For this reason, actual N's are given with each data analysis or reflected in *p*-values.

Procedure

Adolescents were tested in schools or community centers in small groups. The practical intelligence test (YSPI) was administered first, then the tests of fluid and crystallized abilities. Finally, adolescents provided ratings. Adults who provided ratings did so at schools or community centers. All testing of adolescents was done with parental informed consent as well as the adolescents' assent.

Results

Reliabilities

Coefficient alpha (internal-consistency) reliabilities for our main measures were .81 for the Cattell for the total score (.51 for series completions, .49 for classifications, .71 for matrix completions, and .69 for topology), .92 for the Mill Hill for the combined forms (.82 for Form A and .88 for Form B), and .72 for the YSPI. The YSPI measured very diverse elements of practical knowledge across multiple domains (as described above), which is why its internal consistency would be expected to be, and was, lower (internal consistency was .58 for *Sea and River Knowledge* and .57 for *Land Knowledge*). The Cattell was speeded, so its alpha internal-consistency reliability was somewhat suppressed.

Basic Statistics

Table 1.1 shows basic statistics for all indicators used in the study.

Group Comparisons

Independent variables. To investigate the group differences, we carried out a series of multivariate and univariate analyses of variance. The first analysis compared group-specific scores on the total indicators of fluid, crystallized, and practical abilities; the multivariate effect of the group variable was significant (Pillai's Trace=.349, $F_{9,489}=7.1$, $p<.001$). However, the follow-up univariate analyses indicate that groups differed on the crystallized (subtest 1: semi-urban boys and girls; subtest 2: girls semi-urban and rural; subtest 3: rural boys and girls; $F_{3,166}=10.4$, $p<.001$) and practical abilities scores (subtest 1: rural boys and girls; subtest 2: rural girls and semi-urban boys and girls; $F_{3,166}$=5.7, p<.001). This pattern of results, in general, holds for the subtests of the three abilities: Overall, there were no group differences on the fluid abilities subtests, and the patterns for crystallized and practical abilities were similar to those for the total scores (see Table 1.1).

Dependent variables. Because of the sample composition of the dependent variables (the *Hunting Skills* indicators were collected only for boys and the *Household Skills* indicators were collected only for girls), we conducted three different sets of analyses. The first set of multivariate analyses investigated the group differences for *Thinking Skills* and *Respect for Elders* indicators—the multivariate effect of the group variable was significant (Pillai's Trace=.173, $F_{6,376}$=5.9, p<.001). However, the univariate analyses indicated that there was a significant group effect only for the *Thinking Skills* variable: rural boys outperformed everyone else, but rural girls did the worst ($F_{3,191}$=12.1, p<.001). The other two analyses were univariate analyses for boys and girls separately. For the indicator of *Hunting Skills*, rural boys outperformed urban boys, but the *F*-statistic was only borderline significant ($F_{1,88}$=3.1, p<.1). For the indicator of *Household Skills*, urban girls outperformed rural girls ($F_{3,132}$=10.3, p<.001).

Table 1.1

<u>Descriptive Statistics</u>

Subgroup Measure	Rural Boys Mean/*SD*	Semi-urban Boys Mean/*SD*	Rural Girls Mean/*SD*	Semi-urban Girls Mean/*SD*	All Boys and Girls Mean/*SD*
The Cattell Culture Fair					
1. Series Completions	9.1/1.7	9.3/2/5	8.7/1.6	9.4/1.6	9.0/1.8
2. Classifications	7.8/1.8	8.7/2.3	7.7/1.8	8.5/2.3	7.8/2.0
3. Matrix Completions	7.8/2.4	8.8/3.3	8.1/2.2	8.8/1.7	8.1/2.5
4. Topology	4.0/2.1	4.9/2.3	3.9/2.0	4.1/2.2	4.1/2.1
5. Total Score	28.6/5.5	31.4/8.4	28.4/5.1	30.5/6.2	29.2/5.9
The Mill-Hill Vocabulary Test					
1. Form A	16.6/3.4	21.5/3.3	17.1/3.9	19.6/3.6	17.8/3.9
2. Form B	15.4/4.4	20.8/7.3	16.8/4.1	19.2/5.9	17.2/5.2
3. Total Scores	32.0/7.1	42.1/9.0	34.0/7.4	38.2/8.5	35.0/8.3
The YSPI					
1. Sea and River Knowledge	9.5/2.8	6.7/2.7	8.9/2.7	6.6/2.2	8.5/2.9
2. Land Knowledge	9.1/2.8	8.3/3.9	8.6/2.3	8.7/3.3	8.7/2.8
3. Total Scores	18.6/4.4	15.1/6.0	17.4/3.7	15.1/4.2	17.2/4.5
The Criteria Ratings					
1. Thinking Skills	.53/.94	.25/.74	-.45/.91	.21/.1.0	.10/1.0
2. Respect for Elders	.11/1.0	-0.21/1.0	-.07/.93	.08/.93	-.01/1.0
3. Hunting Skills	.18/1.1	-.19/.82			.05/.99
4. Household Skills			-.22/1.1	.32/.85	.03/1.0

Correlations

Table 1.2 shows first-order correlations between all indicators used in the study.

Between measures of fluid and crystallized abilities. Based on past research and conventional hierarchical models (e.g., Carroll, 1993), we predicted that the two conventional psychometric ability tests would show a significant correlation with each other, which they did. The correlation was .48 for the total scores ($p<.001$, $N=175$). The correlations between the subtests were of comparable magnitude and are shown in Table 1.2.

Between the practical intelligence measure and measures of fluid and crystallized abilities. Based on our own past research (see, e.g., Sternberg et al., 2000), we predicted that correlations between our practical intelligence measure (the YSPI) indicators and measures of fluid and crystallized abilities would be modest and positive or nil. We were largely but not entirely correct in this prediction.

The correlations between the subtests of the YSPI, Mill-Hill, and Cattell are shown in Table 1.2. For the total sample, of the 12 correlations, only 2 were significant, both with *Land Knowledge,* one with an indicator of fluid and one with an indicator of crystallized intelligence. Consistent with previous data (reviewed in Sternberg et al., 2000), correlations between measures of practical and crystallized intelligence are non-significant or trivial statistically. The reason is that crystallized intelligence tests measure knowledge valued by the elite of a society (e.g., vocabulary words that generally are used only rarely in conversations, factual information that is rarely called upon in daily life, and reading comprehension for passages that are above the level of many readers) and practical intelligence tests measure knowledge valued by the general population in everyday life. Thus, someone could have high practical intelligence, but achieve rather modest scores on tests such as the Verbal SAT or the Miller Analogies Test, both of which require, for mastery, a level of verbal sophistication beyond that of many people in the population. The correlations for the two groups of the adolescents (rural and semi-urban) are shown in Table 1.3.

Between the subscale indicators of the YSPI. The two subscales of the YSPI correlated with each other at $r=.46$ ($p<.001$) for the total sample. The correlations in the two group of adolescent—those, living in the rural and those living in the semi-urban environments—are shown in Table 1.3.

Between the four ratings of practical skills. Recall that there were four relevant ratings of practical skills: everyday thinking skills, respect for elders, hunting skills (for boys), and household skills (for girls). The correlations between the four criteria indicators for the total sample are shown in Table 1.2. The results, in general, reveal a positive manifold in the relations between these skills. In other words, these results suggest that the four ratings are assessing related skills, but certainly not the same skills. The correlations for the two groups of the adolescents (rural and semi-urban) are shown in Table 1.3.

Table 1.2

Intercorrelations

Indicators	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
The Cattell Culture Faie												
Series Completions (1)	1											
Classifications (2)	.48***	1										
Matrix Completions (3)	.47***	.40***	1									
Topology (4)	.24***	.27***	.28***	1								
The Mill-Hill Vocabulary Test												
Form A (5)	.36***	.31***	.38***	.33***	1							
Form B (6)	.35***	.30***	.27***	.26***	.68***	1						
The YSPI												
Sea and River Knowledge (7)	.12	.08	.09	.14	.08	.08	1					
Land knowledge (8)	.14	.08	.16*	.08	.12	.21	.46***	1				
The Criteria Ratings												
Thinking Skills (9)	.17*	.19**	.10	.19*	.23	.24**	.07	.17*	1			
Respect for Elders (10)	.17*	.09	.20**	.03	.09	.07	.08	.09	.16*	1		
Hunting Skills (11)	-.16	-.20	-.06	-.02	.04	-.13	.39***	.35***	.29**	-.14	1	
Household Skills (12)	.24*	.16	.27**	.02	.14	.21*	-.17	.09	.38***	.37***	N/A	1

Note. Asterisks signify the following *p*-values: * for $p<.05$; ** for $p<.01$; and *** for $p<.001$.

Table 1.3

Intercorrelations in the Two Groups of Adolescents

Indicators	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
The Cattell Culture Faie												
Series Completions (1)	1	.59***	.60***	.45***	.25	.17	.13	.08	.05	.06	-.10	.32
Classifications (2)	.38***	1	.47***	.41***	.30*	.16	.08	-.06	.34*	.17	-.17	.26
Matrix Completions (3)	.37***	.33***	1	.27*	.28*	.16	.18	.11	-.03	.17	-.17	.36*
Topology (4)	.10	.15	.28**	1	.37**	.24	.34*	.14	.12	-.13	.19	.24
The Mill-Hill Vocabulary Test												
Form A (5)	.41***	.26**	.38***	.29***	1	.44***	.24	.09	.25	-.09	.10	.36*
Form B (6)	.44***	.33***	.28**	.22*	.72***	1	.22	.19	.29*	.01	-.16	.22
The YSPI												
Sea and River Knowledge (7)	.22*	.21*	.16	.13	.35***	.31***	1	.54***	-.09	.13	.23	-.03
Land knowledge (8)	.22*	.26**	.24**	.06	.31***	.37***	.33***	1	.01	.04	.19	.01
The Criteria Ratings												
Thinking Skills (9)	.19*	.08	.11	.20*	.17	.17	.23**	.33***	1	.07	.05	.43**
Respect for Elders (10)	.19*	.05	.19*	.07	.11	.08	.05	.13	.20*	1	-.41**	.36*
Hunting Skills (11)	-.19	-.24	.02	-.06	.14	-.05	.39***	.39***	.34**	-.06	1	N/A
Household Skills (12)	.13	.04	.18	-.12	-.09	.08	-.07	.25*	.23	.39***	N/A	1

Note. Correlations shown below the diagonal were obtained in the rural sample; correlations shown above the diagonal were obtained in the semi-urban sample. Asterisks signify the following *p*-values: * for $p<.05$; ** for $p<.01$; and *** for $p<.001$.

Between conventional psychometric measures (fluid/crystallized) and ratings of practical skills. We expected modest but probably significant correlations between the conventional psychometric measures and the ratings of adaptive skills, given that *g* predicts so many things (Jensen, 1998). The data were generally consistent with this prediction.

As apparent from Table 1.2, for the total sample, most of the significant correlations between peer and adult ratings and indicators of fluid and crystallized intelligence were observed for the *Thinking Skills* ratings. It is also of interest that *Hunting Skills* in boys did not correlate with any conventional intelligence indicators. Table 1.3 depicts the pattern of correlations between the ratings and the indicators of the conventional intelligence in the two subsamples of adolescents.

Overall, these results suggest that the conventional psychometric measures provide modest prediction of some rated skills (e.g., *Thinking Skills* and *Respect for Elders*), but not others (e.g., *Hunting Skills*) valued by Yup'ik people.

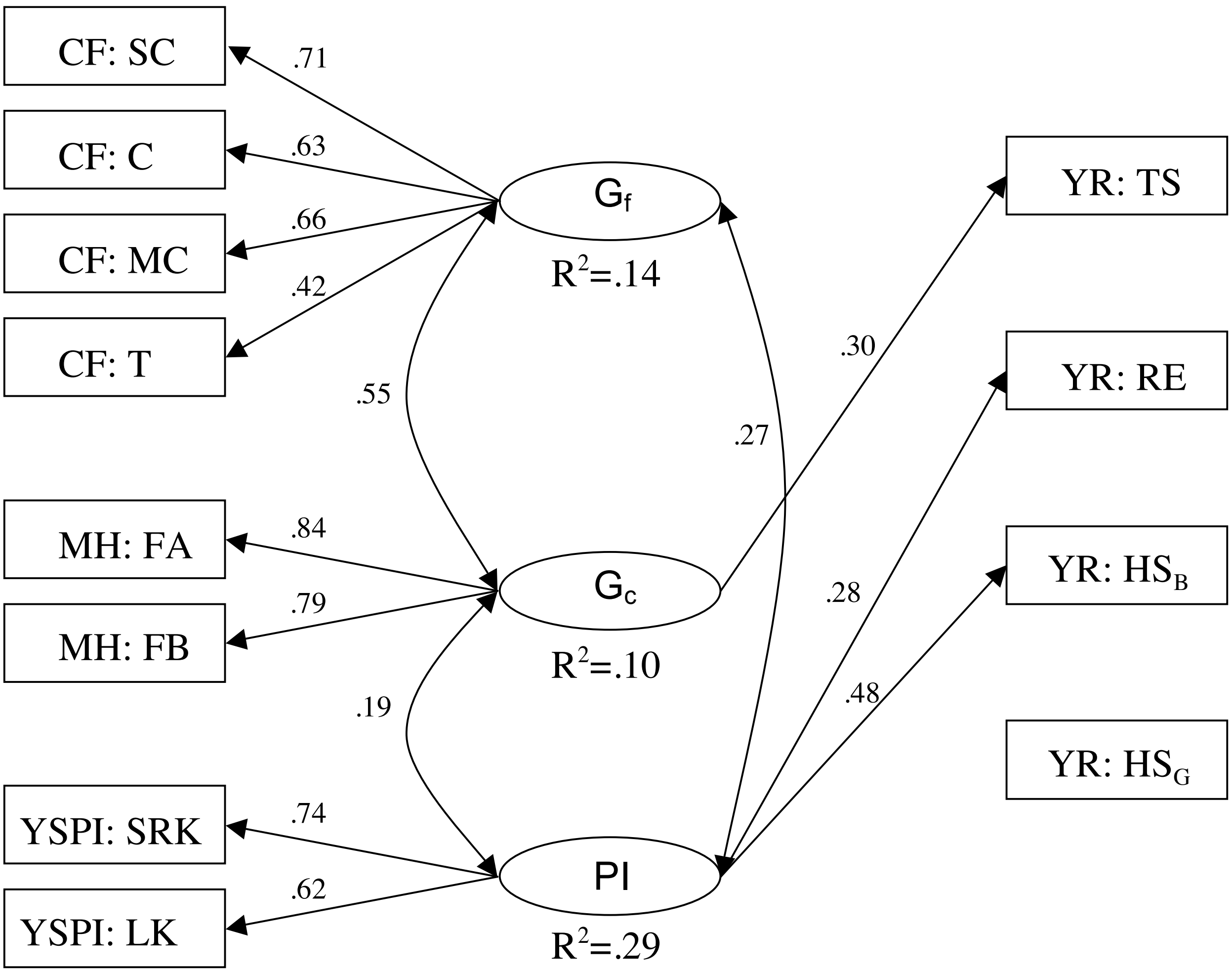
Between the practical intelligence measure (YSPI) and ratings of practical skills. The correlations between the indicators of YSPI and the ratings are shown in Table 1.2 (for the total sample) and in Table 1.3 (for subsamples). In general, the results suggest that our practical intelligence measure (YSPI) provided modest prediction of adaptive skills as expressed by ratings of adults and peers in the total sample (*Thinking Skills* and *Hunting Skills*) and moderate prediction of adaptive peer and adult ratings among the rural adolescents (*Thinking Skills*, *Hunting Skills*, and *Household Skills*).

Structural Equation Modeling

To further investigate the patterns of observed relationships between independent and dependent variables, we have fitted a number of structural equation models. In these models, we attempted to predict peer and adult ratings of the Yup'ik-valued traits based on indicators of fluid, crystallized, and practical abilities.

Full model for the total sample combined with missing data. As indicated above, there were missing data points in this dataset. Moreover, ratings of *Hunting Skills* were obtained for boys only whereas ratings of *Household Skills* were obtained for girls only. To avoid listwise deletion, the covariance matrix for these measures was estimated using the full-information maximum likelihood (FIML, Allison, 1987; Dempster, Laird, & Rubin, 1977; McArdle, 1994) method as implemented in Mplus (Muthén & Muthén, 2002). Specifically, we fitted the MIMIC model to the data (Muthén & Muthén, 2002). In this model, we specified three latent variables, each of which was determined by multiple indicators. In detail, the fluid intelligence latent structure was determined by four subtests of the Cattell; the crystallized intelligence latent structure was defined through two forms of the Mill Hill; and the practical intelligence latent variable was defined by the two indicators of the YSPI (*Sea and River Knowledge* and *Land Knowledge*). All three latent variables were regressed on the four criteria ratings—*Thinking Skills*, *Respect for Elders*, *Hunting Skills*, and *Household Skills*.

First, we fitted the model (Model 1) without sub-grouping (i.e., without indicating the rural versus semi-urban subsamples). The overall fit of the model was satisfactory—χ^2_{37}=35.7 (*p*=.53), compared to the fit for the baseline model—χ^2_{60}=417.2 (*p*=.00). The model's CFI was 1.00 and its SRMR was .037. Figure 1.1 presents the structure of the model and depicts standardized coefficients. As presented in Figure 1.1, the R^2 for the latent variables were .14 for fluid intelligence, .10 for crystallized intelligence, and .29 for practical intelligence. The correlations between the latent structures were as follows: Fluid intelligence correlated with crystallized intelligence at .55 (*t*=4.8), whereas practical intelligence correlated with fluid intelligence at .27 (*t*=2.5) and with crystallized intelligence at .19 (*t*=1.8).



CF: SC—The Cattell subtest Series Completions; CF: S—The Cattell subtest Classifications; CF: MC—The Cattell subtest Matrix Completions; CF: T—The Cattell subtest Topology; MH: FA—The Mill-Hill subtest Form A; MH: FA—The Mill-Hill subtest Form B; YSPI: SRK—Yup'ik Scale of Practical Intelligence subtest *Sea and River Knowledge*; YSPI: LK—Yup'ik Scale of Practical Intelligence subtest *Land Knowledge*; YR: TS—Yup'ik ratings, *Thinking Skills*; YR: TS—Yup'ik ratings, *Respect for Elders*; YR: HS_B—Yup'ik ratings, *Hunting Skills*; YR: HS_G—*Household Skills*.
Note: Only statistically significant coefficients are shown.

Figure 1.1. A diagram for model 1.

Second, we fitted the model (Model 2) that specified the structure of rural versus semi-urban subsamples. The overall fit of the model was also satisfactory—χ^2_{84}=85.4 (*p*=.44), compared to the fit for the baseline model—χ^2_{120}=488.7 (*p*=.00). The model's CFI was .996 and its SRMR was .071. Because Model 1 showed a comparable satisfactory fit and was more parsimonious than this model, preference should be given to the simpler model (i.e., the model presented in Figure 1.1). Of interest, however, is whether the loadings in the two groups (rural and semi-urban) were different for any variables (as the correlations for some variables differed across the subsamples of rural and semi-urban adolescents, as is apparent from Table 1.3). Table 1.4 presents the parameter estimates for the two models of interest. The R^2 for the latent variables were (a) .20 for fluid intelligence, .06 for crystallized intelligence, and .53 for practical intelligence in the rural sample and (b) .14 for fluid intelligence, .28 for crystallized intelligence, and .05 for practical intelligence in the semi-urban sample. The correlations between the latent structures were as follows: (a) fluid intelligence correlated with crystallized intelligence at .64 (*t*=4.5), whereas practical intelligence correlated with fluid intelligence at .67 (*t*=4.1) and with crystallized intelligence at .66 (*t*=4.4) in the rural subsample and (b) fluid intelligence correlated with crystallized intelligence at .31 (*t*=1.8), whereas practical intelligence correlated with fluid intelligence at .15 (*t*=1.1) and with crystallized intelligence at .36 (*t*=2.6) in the semi-urban subsample. These differences in the patterns of correlations are of interest, but should be interpreted with caution, since the size of the samples on which these correlations were obtained are small and the standard errors for these correlations are not available.

Group-specific modeling. Because the full model was fitted with missing data (i.e., only boys were rated for *Hunting Skills* and only girls were rated for *Household Skills*), we re-fitted the two models specified above (Model 1 and Model 2) to boys- and girls-only data.

Boy-specific models. As described above, first we fitted a model that replicated the model described above, with one exception—the trait of *Household Skills* was absent from the model. In other words, Model 1 was re-fitted for boys only and without the *Household Skills* variable. All fitting indices for this model were satisfactory: χ^2_{32}=27.7 (*p*=.69), compared to the fit for the baseline model—χ^2_{52}=239.9 (*p*=.00). The model's CFI was 1.00 and its SRMR was .050. The model (Model 3) resulted in the following R^2 for the latent variables: .10 for fluid intelligence, .11 for crystallized intelligence, and .31 for practical intelligence. The correlations between the latent structures were as follows: fluid intelligence correlated with crystallized intelligence at .40 (*t*=2.6), whereas practical intelligence correlated with fluid intelligence at .21 (*t*=1.6) and with crystallized intelligence at .08 (*t*=0.7). The parameter estimates for this model are shown in Table 1.4.

The second model for boys (Model 4) was similar to Model 3, but Model 4 just as for Model 2, included rural or semi-urban subgroups. The fit statistics for this model (Model 4) were as follows: χ^2_{74}=76.3 (*p*=.40), compared to the fit for the baseline model—χ^2_{104}=292.7 (*p*=.00); CFI was .988 and the SRMR was .111. Table 1.4 presents the parameter estimates for Model 6. The R^2 for the latent variables were (a) .19 for fluid intelligence, .17 for crystallized intelligence, and .49 for practical intelligence in the rural sample and (b) .02 for fluid intelligence, .21 for crystallized intelligence, and .06 for practical intelligence in the semi-urban sample. The correlations between the latent structures were as follows: (a) fluid intelligence correlated with crystallized intelligence at .51 (*t*=2.9), whereas practical intelligence correlated with fluid intelligence at .62 (*t*=3.1) and with crystallized intelligence at .55 (*t*=3.0) in the rural subsample and (b) fluid intelligence correlated with crystallized intelligence at .40 (*t*=1.6), whereas practical intelligence correlated with fluid intelligence at -.01 (*t*=-0.1) and with crystallized intelligence at .14 (*t*=0.8) in the semi-urban subsample. Here, once again, the difference between rural and semi-urban samples' parameter estimates needs to be interpreted with caution due to the limited sample sizes and unavailability of standard errors for the estimates.

Table 1.4

<u>Parameter Estimates From the Fitted SEM Models</u>

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CF: Series Completions	**.71**	**.64/.83**	**.75**	**.69/.87**	**.68**	**.60/.81**
CF: Classifications	**.63**	**.57/.68**	**.69**	**.64/.74**	**.59**	**.53/.66**
CF: Matrix Completions	**.66**	**.55/.70**	**.73**	**.62/.76**	**.58**	**.41/.62**
CF: Topology	**.42**	**.35/.50**	**.34**	**.28/.43**	**.46**	**.40/.58**
MH: Form A	**.84**	**.84/.78**	**.78**	**.80/.84**	**.83**	**.87/.70**
MH: Form B	**.79**	**.85/.54**	**.89**	**.87/.61**	**.77**	**.85/.48**
YSPI: Sea & River	**.74**	**.61/1.0**	**.79**	**.65/1.1**	**.88**	**.55/1.0**
YSPI: Land	**.62**	**.49/.48**	**.71**	**.55/.59**	.37	**.39/.37**
CR: Thinking Skills	.19	**.32**/-.02	.16	.22/.-.00	**.27**	.21/.38
Fluid	**.30**	.24/.25	**.32**	**.38/.49**	**.38**	.20/.42
Crystallized	.05	.17/-.08	.04	.02/.13	.05	**.61**/-.13
Practical						
CR: Respect for Elders	.10	.13/-.03	.18	.29/.12	.08	-.01/.14
Fluid	.01	.11/-.28	.01	.16/.-.29	.02	.02/-.12
Crystallized	**.28**	.13/.23	**.24**	**.30**/.07	.11	-.19/.30
Practical						
CR: Hunting Skills	-.15	**-.33**/.05	-.19	-.26/.20		
Fluid	-.11	-.10/.01	-.21	-.09/.-.05		
Crystallized	**.48**	**.62**/.17	**.52**	**.65**/.24		
Practical						
CR: Household Skills	.19	.10/.38			.20	.12/.23
Fluid	.07	-.09/.39			.07	-.04/.32
Crystallized	-.18	.04/-.09			-.21	.05/-.07
Practical						

Note: For Models 2, 4, and 6, the first column presents the estimates from the rural subsample, and the second column contains the estimates for the semi-urban subsample.

Girl-specific models. The first model for girls (Model 5) was similar to Model 1 above, only it did not include the ratings on *Hunting Skills*. This model provide an acceptable fit, although the fit was the worst of all surveyed models so far, χ^2_{32}=46.6 (p=.05), compared to the fit for the baseline model—χ^2_{52}=235.2 (p=.00). The model's CFI was .920 and its SRMR was .065. The R^2 for the latent variables were .18 for fluid intelligence, .17 for crystallized intelligence, and .03 for practical intelligence. The correlations between the latent structures were as follows: fluid intelligence correlated with crystallized intelligence at .65 (t=4.1), whereas practical intelligence correlated with fluid intelligence at .27 (t=1.9) and with crystallized intelligence at .28 (t=2.3). The parameter estimates for this model are shown in Table 1.4. The second model for girls (Model 6) was similar to Model 5, but Model 6 took into account the community of origin (rural or semi-urban) of the girls in the sample. The fit statistics for this model (Model 6) were as follows: χ^2_{74}=82.7 (p=.22), compared to the fit for the baseline model—χ^2_{104}=300.7 (p=.00); CFI was .956 and the SRMR was .097. Table 1.4 presents the parameter estimates for Model 6. The R^2 for the latent variables were (a) .07 for fluid intelligence, .04 for crystallized intelligence, and .35 for practical intelligence in the rural sample and (b) .29 for fluid intelligence, .39 for crystallized intelligence, and .11 for practical intelligence in the semi-urban sample. The correlations between the latent structures were as follows: (a) fluid intelligence correlated with crystallized intelligence at .80 (t=3.7), whereas practical intelligence correlated with fluid intelligence at .53 (t=2.0) and with crystallized intelligence at .80 (t=3.4) in the rural subsample and (b) fluid intelligence correlated with crystallized intelligence at .36 (t=1.6), whereas practical intelligence correlated with fluid intelligence at .41 (t=2.3) and with crystallized intelligence at .57 (t=2.9) in the semi-urban subsample. Once again, the difference between the patterns of correlations linking the latent variables is of interest (keeping the limitations of the sample sizes in mind). However, given that the zero-order correlations are not of this magnitude (but generally significant for rural and not significant for semi-urban groups of adolescents), clearly, there is a need to replicate this effect before too much weight is put on it.

Discussion

We found that children in the urban community outperformed children in the rural community on the test of crystallized intelligence; children in the rural community, however, outperformed children in the urban community on the test of practical intelligence. We also found that a measure of practical intelligence assessing tacit knowledge provided prediction of rated practical skills that was complementary and, in certain instances, incremental to the prediction provided by conventional measures of fluid and crystallized intelligence. In the rural Yup'ik communities for which our test was created, the practical test was the best predictor of Yup'ik-valued traits, with R^2(s) for practical intelligence latent variable ranging from 35% (for girls only) to 53% (for the total sample). It provided lesser prediction in the semi-urban community, as would be expected, given that members of the semi-urban community engaged in the activities assessed by the YSPI far less than did members of the rural communities (the R^2(s) for the latent variable of practical intelligence ranged from 5% in the combined sample to 11% in the girls' sample).

However, the model for the combined sample (boys and girls) amalgamating rural and semi-urban groups of adolescents as well as the joint model for boys fitted as well as the multigroup rural/semi-urban models. Two observations are important to note in the analyses of these models (Model 1 and Model 3). First, consistent with the discussion above, the models explained substantially more variance in the latent variable of practical intelligence than in either crystallized or fluid intelligence, indicating substantial predictive power of the measures of practical skills for the indicators of Yup'ik-valued traits. Second, whereas the correlations between the latent indicators of conventional abilities are high (.55 and. 40), the correlations between both fluid and crystallized intelligences and practical intelligence are low (.27 and .19 for Model 1 and .21 and .08 for Model 3). However, when these correlations are examined in the subsample of the rural adolescents, the pattern is different—the latent variable for practical intelligence tend to correlate significantly with indicators of fluid and crystallized intelligence. Although these findings are of interest, given that the observed correlations are significantly lower and the sample sizes are small, these connections should be explored further in the future research before their significance is fully understood.

In terms of theories of intelligence, our results suggest that tests of practical intelligence, in particular, as measured by tests of everyday domain specific knowledge, can provide useful supplements to more conventional tests of more academic, analytical abilities (Neisser, 1976; Sternberg et al., 2000). Analytical and practical intelligence may show quite distinctive patterns of individual as well as developmental differences (Carraher et al., 1985; Ceci & Roazzi, 1994; Cornelius & Caspi, 1987; Denney & Palmer, 1981; Lave et al., 1984; Scribner, 1984; Sternberg, 1997). An ideal assessment of intelligence thus would measure practical as well as academic analytical skills. The former kind of measure, of course, supplements rather than replaces the latter. According to the triarchic theory, intelligence overall involves a blend of analytical and practical, as well as creative skills.

In terms of cultural settings, our results are largely consistent with the theories and data of Serpell (1976, 1993, 2000), Kearins (1981), the Laboratory of Comparative Human Cognition (1982) in suggesting that members of different cultures may more develop skills that are adaptive in their own cultures and less develop skills that are adaptive in other cultures. Thus, it is possible to compare performances of members of different cultures only in a conditional way (Cole, 1996; Laboratory of Comparative Human Cognition, 1982), taking into account the kinds of behavior that are adaptive in a given cultural setting. And in making such comparisons, it is important to realize that what appears to be the same test may not be testing the same skills in different cultural settings (Greenfield, 1997).

One could argue, of course, that the kind of practical intelligence we measured did not truly reflect practical intelligence or even intelligence at all. But in terms of the kinds of knowledge and skills considered adaptive in the culture we have studied, we believe our measure was of intelligence in the sense in which the term most often has been used (Thorndike, 1921; Sternberg & Detterman, 1986), namely, as a construct reflecting cultural adaptation. One further could argue that folk knowledge somehow should not "count." But it counts in the culture we studied and is the basis for everyday survival. And if intelligence is not about individual differences in everyday survival skills, what is it—or should it be—about?

Our study is characterized by a number of weaknesses. Specifically, our sample size is clearly not big enough to differentiate well the groups of interest (rural boys and girls and semi-urban boys and girls). However, collecting data in Alaska villages is a huge challenge, both in terms of the distances between the remotely situated villages and the weather conditions that often make these distances very challenging to traverse. To our knowledge, this study was one of the very few that collected performance data from a sample of this size comprising Yup'ik adolescents. Moreover, we were not always able to describe accurately the ethnic background of adolescents in the sample. Although we asked the question of ethnic identity, many teenagers preferred not to answer this question. For those adolescents who currently live in Dillingham, we had no information on the duration of their stay in town. Clearly, such detailed information would have been helpful in explaining the patterns of performance on YSPI among the adolescents in Alaskan villages and Dillingham. Moreover, it appears that, on all of the study indicators, the rural girls showed the lowest levels of performance. It is possible that our pattern of results is real and indicates the presence of "double disadvantage" for the rural girls. The double disadvantage would be that (a) they under-perform on the academic measures as compared to the urban youth due to the rural-urban disadvantage and (b) they are under-rated on indicators of Yup'ik values due to the male-female inequality observed in traditional societies. Another possibility is that our assessments were not successful in capturing the domains in which these girls excel. Finally, it would have been very helpful to develop even more domain specific items tapping into various Yup'ik-specific activities (e.g., story-knifing, knowledge of Yup'ik language), and we hope to do so in our future work.

Our results are largely consistent with a wide body of knowledge suggesting that measures of conventional IQ-like abilities tell a part, but not the whole story of a person's intelligence, broadly conceived. Our study may have some value as a stand-alone demonstration of the importance of practical intelligence. But the study also joins a growing body of knowledge suggesting that practical intelligence can be and often is largely distinct from academic intelligence.

Intervention Study II—Triarchically Based Instruction and Assessment of Sixth-grade Mathematics in a Yup'ik Cultural Setting in Alaska

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Over the better part of the past century, research reports have called for educational programs that connect the culture of the community to the culture of the school, including the use of local languages, local knowledge, and local involvement (e.g., Deyhle & Swisher, 1997; Meriam, Brown, Cloud, & Dale, 1928; Pavel, 1999; Swisher & Tippeconic, 1999). These reports strongly suggest that the cultural divide between school and community is a major factor causing the persistent gap in the academic performance of different groups, and in particular, between the performance of American-Indian/American-Native (AI/AN) students and their non-native peers. Historically, the federal government's "remedy" promulgated a policy of language and cultural exclusion (Deyhle & Swisher, 1997). Yet Alaskan Native students and their communities—rather than the schools or government—were often blamed for school failure. Furthermore, everyday knowledge was disconnected from formal schooling, resulting in a disjunction between what students know and what schools teach. In short, conflict exists between community and schools. These factors as well as rapid teacher turnover, teachers teaching out of their content area, and the low percentage of local teachers (Pavel, 1995) resulted in AI/AN students' underperformance in core academic subjects, particularly mathematics (National Center for Education Statistics [NCES], 2001).

Alaska mirrors the national trend; in fact, Yup'ik Eskimo students in rural southwest Alaska appear to score even lower on standardized tests than do other Alaskan Native groups (Alaska Department of Education and Early Development, n.d.). Further, a report from the Alaska Natives Commission (1993) found 19 out of 20 Native school districts scoring, on average, below the 22nd percentile in at least one of the core subject areas on standardized fourth, sixth, and eighth grade achievement tests, and a low 67% rate of high school completion among Alaskan Native students. Similarly, in rural Alaska, schools are almost exclusively composed of students from Native cultures (Kawagley, Norris-Tull, & Norris-Tull, 1998), whereas teachers are almost exclusively composed of Euro-Americans who leave on average after between 2 and 4 years (Lipka, 1999).

The ongoing nature of these difficulties was the impetus for an educational initiative in Yup'ik Eskimo communities. Recent initiatives within Yup'ik communities, in collaboration with university researchers, have begun to reconcile the culture of the community with the culture of the school to create more authentic and culturally responsive learning environments (Kawagley & Barnhardt, 1999a; Lipka, Mohatt, & the Ciulistet Group, 1998).

The Yup'ik Culture

The Yup'ik culture is one of a number of Alaska Native cultures. These communities reside primarily in a vast road less area of southwestern Alaska in small, rural villages. A large part of the culture of these communities is subsistence fishing and hunting, and although Western television and radio are prevalent in the homes, the culture remains highly intertwined with the natural environment (Lipka et al., 1998). Yup'ik people are described as having their own way of conceptualizing knowledge, categorizing, and performing everyday tasks (Lipka, 1994).

In 1984, the Yup'ik communities of Akiachak, Akiak, and Tuluksak formed the Yupiit School District to take control over their schools. They held their first community meeting in 1992 to compile a list of the values and beliefs community members wanted transmitted through their classrooms (Kawagley & Barnhardt, 1999b). With the help of community feedback, the district team outlined the following student goals: knowledge of Yup'ik values, culture, and subsistence skills; preparation for work and further education; respect and positive attitudes toward life, learning, and community; development as law-abiding citizens; and ability to communicate in Yup'ik and English (Kawagley & Barnhardt, 1999b). In addition, parent and community involvement was increased in the schools and this involvement became increasingly important as a culturally-based curriculum began to be developed.

Similarly, in the Bristol Bay Region of southwest Alaska, the Ciulistet (Leaders) group was formed. A particularly insightful superintendent, in collaboration with Yup'ik teachers, established this Yup'ik teacher group (Lipka et al., 1998). This was a voluntary group of Yup'ik teachers, including elders, bilingual aides, and university faculty, who studied, conducted research, and worked toward school change (Lipka, 1994; Lipka et al., 1998). One of the goals of this group is the creation of culture-based curriculum, particularly in the domain of mathematics, which integrates math standards developed by the National Council of Teachers of Mathematics (NCTM, 2001) and the culture of the community.

Given the importance of fishing in the Yup'ik communities and the everyday math knowledge required in the fishing camps, fishing emerged as a relevant experience to use in curriculum development (Lipka et al., 1998). Lipka, a long-term researcher associated with Yup'ik teachers and elders from southwest Alaska, obtained funding from the National Science Foundation (NSF) (instructional materials development) to develop math curriculum for elementary school students based on elders' knowledge.[3] Videotapes from fishing camps were collected and analyzed, participant observations were conducted, formal and informal interviews were employed, and meetings and demonstrations were carried out to gather Yup'ik knowledge. Most importantly, elders, Yup'ik teachers, and university researchers engaged in a variety of subsistence activities, in particular, building a fish rack (a device built for drying salmon). The elders' everyday (practical) knowledge of building a fish rack corresponded quite well to more formal school mathematics, specifically, geometry and physical proofs of a rectangle (see Lipka et al., 1998, for a more complete description of this process).

The knowledge gathered through this process was then used to develop mathematics curriculum that was culturally relevant, with the goals of engaging students in a process of constructing a system of mathematics based on their cultural knowledge and connecting students' knowledge of 'their mathematics' through comparisons with other aboriginal and Western systems (Lipka, 1994).

Culture and Curriculum: The Role of Triarchically Defined Intelligence

The concept of culture-based curriculum has received increased attention recently as indigenous groups teach such varying topics as "elastic geometry and storyknifing" (Lipka, Wildfeuer, Wahlberg, George, & Ezran, 2001), the science of studying fish behavior, bird migratory behavior, ebb and flow of tides, currents in rivers (Kawagley et al., 1998), and health care (Whitten, 1995). Indigenous groups around the world have been working to reconcile Western worldviews and native culture in dynamic educational settings that value the role of spirituality as well as connections to land, language, and ancestry (Ah Nee-Benham & Cooper, 2000).

Case studies and classroom observations point to increased student involvement and investment in education that is in concert with their community life (e.g., Lipka et al., 1998). However, there is a need for more empirical work examining the academic benefits of teaching students with strategies and curriculum from their culture, and of relating such curriculum to theories of intelligence.

Much of mainstream education is based on the traditional notion of intelligence as a single construct, predominantly, the ability to remember a breadth of information and to think analytically. Thus, much of education focuses on teaching students facts and occasionally teaching them to think analytically. However, across cultural groups both within the United States and around the world, people have different implicit notions of what it means to be intelligent (Sternberg & Kaufman, 1998). Children who come from families where views of intelligence differ from those of the mainstream tend to be viewed by their teachers in school as less intelligent than are children whose parents hold the same views of intelligence as do the school teachers (Okagaki & Sternberg, 1993). This preference of teachers for children whose skills match those the teachers happen to value can put children from many cultural backgrounds at a disadvantage. In particular, the practical abilities valued and demonstrated in Native Alaskan cultures may not be particularly valued as a bases for success by teachers in those schools.

The triarchic theory of successful intelligence posits that (successful) intelligence is the ability to achieve success in life, given one's personal standards, within one's sociocultural context. This success is achieved by capitalizing on one's strengths and compensating for or correcting one's weaknesses through a balance of analytical, practical, and creative abilities. Through this balance, one can adapt to, shape, and select environments within which success is achieved (e.g., Sternberg, 1997, 1999).

Within the context of this theory, intelligence is viewed not simply as a cognitive ability within our heads, but also as a socially mediated construct. This emphasis on the social aspect of intelligence makes this theory uniquely applicable to diverse cultural groups and in particular to the education of culturally diverse students. When intelligence is viewed in this way, education is free to provide an environment that is sensitive to the sociocultural values of the community and to the diversity of paths to success.

The triarchic theory has been applied to instruction and assessment in several different settings, including primary and secondary school social science, natural science, and language arts (Grigorenko, Jarvin, & Sternberg, 2002; Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999; Sternberg, Torff, & Grigorenko, 1998). The study reported here represents a first attempt to apply the theory to mathematics curriculum. The study also is a first attempt to apply the theory in a Native-American cultural setting, using materials specifically created for that setting.

The current curriculum, the Fish Racks module, was developed as part of the larger National Science Foundation Instructional Materials Development project (Lipka, 1994). This research project connected the existing Fish Rack module with the theoretical goals of integrating Yup'ik concepts of culture with the triarchic theory of successful intelligence. The curriculum employed teaching strategies derived from Yup'ik culture, such as teaching and mentoring from elders in the communities and the tradition of building fish racks, to study the mathematical concepts of area and perimeter. Such strategies are consistent with the contextual subtheory of the triarchic theory, according to which an important aspect of intelligence is its particular diverse applications in individual cultural-contextual settings. In addition, the theory of successful intelligence and, more specifically, the concept of triarchic teaching for successful intelligence (Sternberg & Grigorenko, 2000) contributed to the creation of activities that involved the analytical and memory aspects of traditional curriculum, the practical activities at the heart of fish rack building, and creative activities that required students to think in novel ways about geometry. In this way, students from the Yup'ik culture were offered a culturally accessible curriculum that addressed the abilities of different types of skills and learners.

In implementing a curriculum that is both culturally driven and triarchically based, we expect that the students who received this curriculum would demonstrate greater improvement from pretest to posttest than would students who received their regular mathematics curriculum.

Method

Participants

Grade 6 students from seven communities in three school districts in Alaska participated in the mathematics curriculum project. Eight classes of students containing a total of 196 students were taught the concepts of area and perimeter using an Alaskan culturally-based, triarchic curriculum and five classes containing 55 students were taught the same subject matter using conventional textbook-based curriculum. Both groups contained students from rural regions with a population that was almost 100% Alaskan Native (predominantly Yup'ik) and urban regions with a population that was approximately 71% ethnically White and 12% Alaskan Native. (The urban settings were "urban" in the context of remote regions of Alaska, where cities tend to be relatively small and isolated.)

In the culturally based, triarchic curriculum group, 51 students lived in rural regions and 145 students lived in urban regions. Among the participants receiving the conventional instruction, 36 students lived in rural regions and 19 in urban regions.

Due to absenteeism a total of 17 students did not complete the pretest and 30 students did not complete the posttest. This resulted in a total of 158 students (35 rural and 123 urban) in the culturally-based triarchic curriculum group and 46 students (29 rural and 17 urban) in the conventional curriculum group being included in the analysis.

Students in Alaska take the Alaska Benchmark Examination in grade 6. Mathematics results from this exam for the students in this study indicate that among rural students in both groups, 46% to 100% of students (depending on the school) were performing less than proficient or not proficient on the benchmark exam. Among the urban students, the results differed across schools, with approximately 15% to 65% of students performing below the benchmark on this exam.

Pretest and posttest measures of the "area and perimeter curriculum" were collected for all the students. Only students who completed both the pre and posttest measures were included in the study sample.

Materials

Experimental group. Teachers in the triarchic, culturally-based curriculum group received a math unit entitled "Fish Racks" as part of the NSF sponsored curriculum "Adapting Yup'ik Elders' Knowledge" (Lipka, 2000). The unit addressed the NCTM standards for the topics of area and perimeter using both native content (building of fish racks) and native teaching strategies (demonstrations by Yup'ik elders). The building of fish racks is a native tradition and requires everyday, practical mathematics to build racks that will be stable, strong, and have sufficient area for placing salmon on them. The math unit comprised two complex problems, each involving a number of different activities revolving around the building of fish racks and the concepts of area and perimeter.

Problem one of the Fish Rack Unit involved two activities and focused on the mathematical concept of the geometry of a rectangle. The practical ideas of building a fish rack were combined with analytical and creative activities to present a triarchically balanced curriculum (see Sternberg, 1998; Sternberg & Grigorenko, 2000). The first activity in the curriculum was a demonstration by a Yup'ik elder of the community of building a fish rack. Practical discussions, such as the use of non-standard body measures, were encouraged during the demonstration. The second activity was developed to allow the students to establish their own rectangular base using rope, and to analytically explore such topics as width, length, and diagonal measurement, estimation, and angles (corners), and "physical" proofs for a rectangle. In the curriculum, the students were then asked to use this new knowledge and create an educational program for television.

Problem two of the Fish Rack Unit involved nine separate activities exploring such mathematical topics as length, shape and perimeter, shape and area, the relationship of perimeter to area, and the relationship of shape to strength. These activities again combined the practical application of the fish rack activities with analytical activities such as evaluating methods of finding the perimeters of different shapes, and creative activities such as coming up with a rhyme or riddle to assist in remembering the fish rack shape that is most practical and efficient.

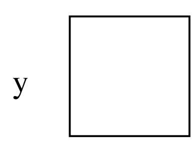
Control group. Teachers in the control group used their mathematics textbooks to teach the concepts of perimeter and area. The approach used in these textbooks is a procedurally based approach for teaching perimeter and a formula based approach for teaching area. The perimeter and area unit covered approximately the same material and began and ended at approximately the same time as the treatment group.

Knowledge-based assessment. Prior to and following the intervention, students completed a test designed to capture their knowledge of area and perimeter concepts. The tests were each composed of 15 questions involving a combination of multiple-choice, short-answer, and open-ended items.

The multiple-choice items were predominantly memory questions, but also included analytical and practical questions. Here is an example of a multiple-choice memory item:

A square has four sides that are the same length. Circle the answer that shows how you would calculate the distance around the outside of a square.

a) $y - y + y - y$
b) $y + y + y + y$
c) $y \times y$
d) $y + y - y$

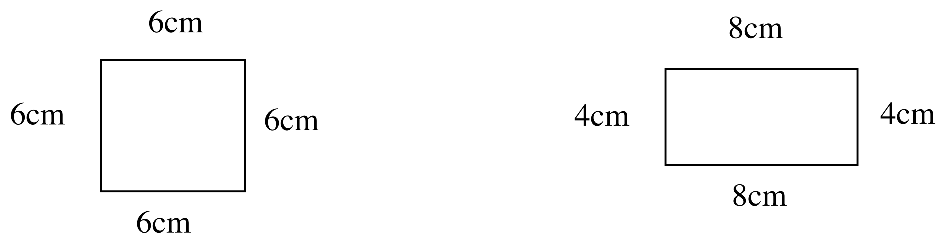


The short answer and open-ended items were a balance of analytical, practical, and creative questions.

Analytical items required the students to employ critical thinking skills such as compare and contrast, evaluate, and judge. For example, students were given two pipe cleaners of the same length and were asked to make a circle with one and an oval with the other. They were then asked to judge which shape had the larger area and to give one reason why the shapes had different areas when the pipe cleaners were the same length.

Practical questions asked the student to apply the concepts of area and perimeter to an everyday situation. For example:

You can have the square piece of your favorite chocolate bar or you can have the rectangular piece. Circle the piece that will give you the most amount of chocolate.



Creative items on the tests asked the students to take the information they had learned about area and perimeter and to use this information in novel ways. For example, students were asked to respond to the following question:

Young children learn new words best when there is a picture or a symbol for them to remember. You want to help the children remember the new word—area. Come up with a symbol or simple picture that helps young children remember what area is.

Procedure

The intervention for students lasted between 3 and 4 weeks; approximate time for instruction was 1 hour a day. The training session for teachers lasted 2 days.

Teachers in the experimental group received training showing them how to teach the geometric concepts using the material and teaching methods derived from the Yup'ik cultural context. Teachers in the conventional textbook-based curriculum (control) group were instructed to teach the area and perimeter concepts from the required textbook, as they usually would. These teachers were given a content-based intervention showing them how they could teach these concepts effectively, using traditional teaching techniques.

Design

The main dependent variables were posttest scores on memory-based, analytically-based, practically-based, and creatively-based achievement measures. The main dependent variable was instructional condition (experimental or control). We also looked at other independent variables as possible covariates, including type of community and participant gender.

Data Analysis

Following the intervention, the pre and posttest measures were scored by three raters—two research assistants with undergraduate degrees in psychology and one senior undergraduate psychology student. The raters were not provided with any information regarding the research design or hypothesis. The raters used a 9-point Likert-type scale to rate the overall quality of the open-ended responses and a forced judgment of right or wrong for short-answer questions that had only one correct response. The raters met frequently as they initially began coding to establish a reliable coding scheme. For the eight items that required subjective ratings on the pretest, the mean inter-rater correlation for pairs of raters was .81. On the posttest, eight items required a subjective rating and the mean inter-rater correlation for pairs of raters was .87. These correlations were deemed sufficiently high to provide reliable assessments of students' performance on these measures.

Principal-components analyses were employed to combine the Likert scale scores of the two raters for each open-ended question. The scores for each open-ended question were then summed in two ways: total continuous sum of all open-ended items, and separate sums for analytical, practical, and creative items for each student on each test. These sums were then transformed into z-scores. The categorical (multiple-choice and short answer) scores were also summed in total for each test and for memory, analytical, practical, and creative items, and then transformed into z-scores. These standardized continuous and categorical scores were then added together to provide five measures each for the pre and posttest assessments: a total test score for each student and four (memory, analytical, practical, and creative) specific scores for each student.

Results

Outcome Measures

As described in the *Method* section, this study used a pre/posttest design with five main outcome measures at each of the pre and posttest times: overall pre and posttest score, and memory, analytical, practical, and creative specific scores.

Preliminary Analysis

Prior to conducting analyses of the main outcome measures, we investigated the association between the outcome measures and potential covariates, such as gender and urban/rural environment (Community). The results revealed no significant difference between girls and boys on either the pre or posttest measures. In contrast, students' performance was significantly associated with the kind of community (urban or rural) in which the students resided and therefore type of community was included in the model for all further analyses.

Treatment effects. Table 2.1 contains descriptive statistics for the 10 indicators of interest (five for each pre and posttest) for the total sample and for each treatment group separately.

Table 2.1

Descriptive Statistics

	Pretest			Posttest		
	Treatment Mean (*SD*)	Control Mean (*SD*)	Total Sample Mean (*SD*)	Treatment Mean (*SD*)	Control Mean (*SD*)	Total Sample Mean (*SD*)
Total Score	.32(2.4)	-.55(2.1)	.12(2.4)	.65(1.9)	-.95(1.9)	.29(2.0)
Memory	.13(1.0)	-.26(1.0)	.04(1.0)	.22(0.8)	-.29(0.9)	.02(.0.8)
Analytical	.06(0.7)	.00(0.8)	.05(0.7)	.15(0.7)	-.26(0.6)	.06(0.7)
Practical	.07(0.7)	-.16(0.7)	.02(0.7)	.17(0.7)	-.32(0.8)	.06(0.7)
Creative	.06(0.8)	-.13(0.5)	.02(0.8)	.11(0.6)	-.09(0.5)	.06(0.6)

Note: Scores are in standard-score (z) units.

To establish whether the two groups of students (the students who received the culturally-based, triarchic curriculum and the students who received the conventional curriculum) had equivalent degrees of knowledge about the topic prior to the intervention, two analyses were conducted—(a) a MANOVA was conducted comparing the means of the two groups on the specific pretest scores (memory, analytical, creative, and practical; see Table 2.1 for descriptive statistics); and (b) an ANOVA comparing the total scores on the pretest.

The MANOVA[4] revealed no significant differences between the two groups at pretest on memory, analytical, creative, and practical indicators (Pillai's Trace $F_{4,189}$=1.8, p>.10). However, there were significant group differences on the univariate ANOVAs for the memory indicators ($F_{1,193}$=5.3, p<.05). Similarly, the univariate ANOVA for the analyses of the total score indicators revealed a significant group difference ($F_{1,193}$=4.7, p<.05). As evident from Table 2.1, these differences are attributable to the advantage of the treatment group.

At the posttest, the treatment group outperformed the control group on all indicators: the MANOVA[5] for the four specific scores was statistically significant (Pillai's Trace $F_{4,189}$=6.4, p>.001) as well as were all univariate analyses: the total score ($F_{1,193}$=24.6, p<.001), memory score ($F_{1,193}$=12.3, p<.001), analytical score ($F_{1,193}$=11.5,

p<.001), practical score ($F_{1,193}$=17.7, p<.001), and creative score ($F_{1,193}$=3.8, p<.05) indicators.

The specifics of these changes were investigated by the means of repeated-measures analyses of variance. Two sets of analyses, one for total test scores and one for memory, analytical, practical, and creative test scores, were conducted with community (rural or urban) included as a covariate.

For the pre-posttest comparison of the total test scores, the repeated analyses of variance revealed a Time x Group interaction effect ($F_{1,191}$=3.8, p<.05), indicating that the two groups gained unequally from pre-to-posttest. In particular, the gains of the students in the treatment group were higher than the gains of the students in the control group. As for between-subject effects, there were two main effects, an effect of Community ($F_{1,191}$=9.1, p<.01) and an effect of Group ($F_{1,191}$=6.0, p<.05). Figure 2.1 shows estimated marginal means at pre and posttest obtained in this analysis.

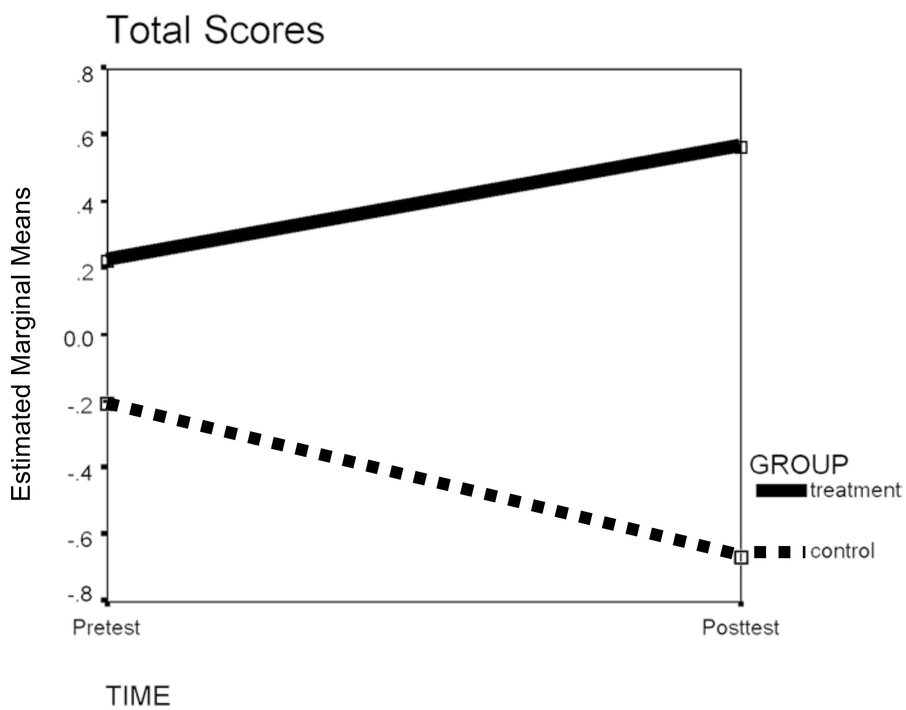


Figure 2.1. Estimated marginal means at pre and posttest.

The second repeated-measures analysis of variance was set up taking into account the effects of Type of Task (memory, analytical, practical, and creative). Similarly to the analyses of total scores, there was a Time x Group interaction effect ($F_{1,191}$=3.8, p<.05), indicating that the two groups gained unequally from pre-to-posttest across multiple indicators. In particular, on all four types of tasks, the gains of students in the experimental group were higher than the gains of the students in the control group.

As for other multivariate effects, there also were effects of Type of Task ($F_{3,189}$=3.3, p<.05), whereby, according to the estimated marginal means, the students did the best on the creative tasks and the worst on the practical tasks, 0.4 and -0.5, respectively; and there were two interaction effects. The first interaction was for Type of Task x Community, $F_{3,189}$=4.1, p<.01; according to the observed means, the children from rural communities performed worst on memory tasks. The second interaction was for Type of Task x Group, ($F_{3,189}$=3.1, p<.05). According to the estimated marginal means, the order of task performance was as follows: for the treatment group—memory (.15), practical (.11), analytical (.08), and creative (.05); and for the control group—creative (.03), analytical (-.07), memory (-.19), and practical (-.21). In addition, as in the analyses reported above, there was also a between-subject effects of Community ($F_{1,191}$=9.1, p<.005). According to the observed means, students from rural communities tend to perform worse than students from urban communities on all tasks. Finally, there was an effect of Group ($F_{1,191}$=6.0, p<.05); according to the estimated marginal means, overall, students in the treatment group performed better than did students in the control group (.10 versus -.11).

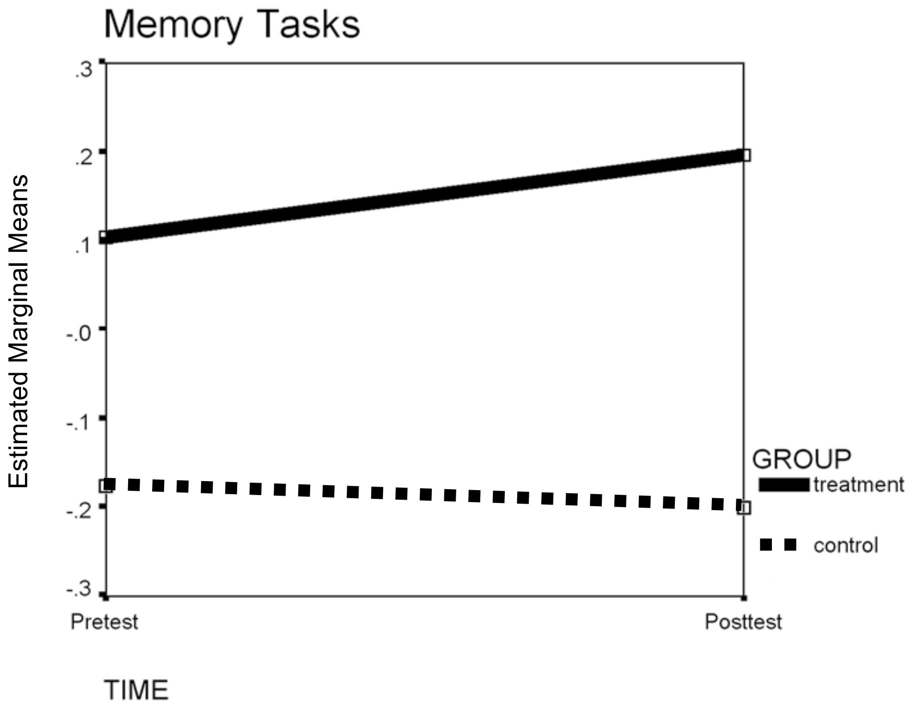
Figure 2.2 shows estimated marginal means for memory, analytical, practical, and creative scores obtained in these analyses. The figure is divided into four parts, one for each task.[6]

Discussion

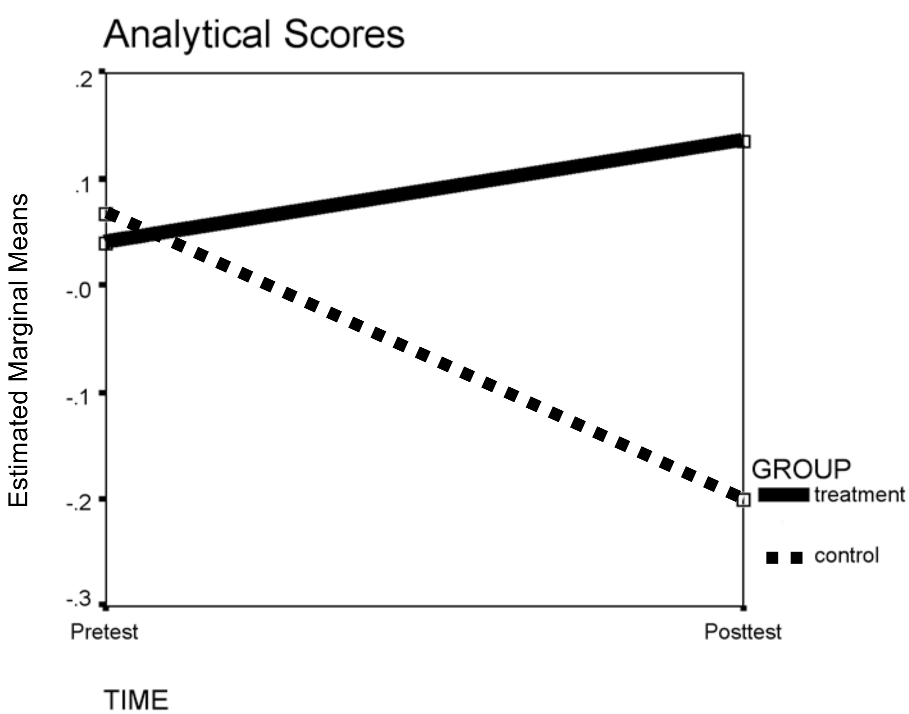
The goal of this study was to examine the efficacy of culturally-based triarchic teaching in comparison with conventional teaching of a geometry unit. The research represented a first attempt to apply triarchic teaching to a mathematics curriculum, as well as a first attempt to apply such teaching using materials adapted to a cultural setting different from that of mainstream U.S. culture, Yup'ik Eskimos in southwest Alaska.

The results showed superior instructional outcomes for all dependent variables, including assessments of memory-based as well as analytically-, creatively-, and practically based achievement.

a.

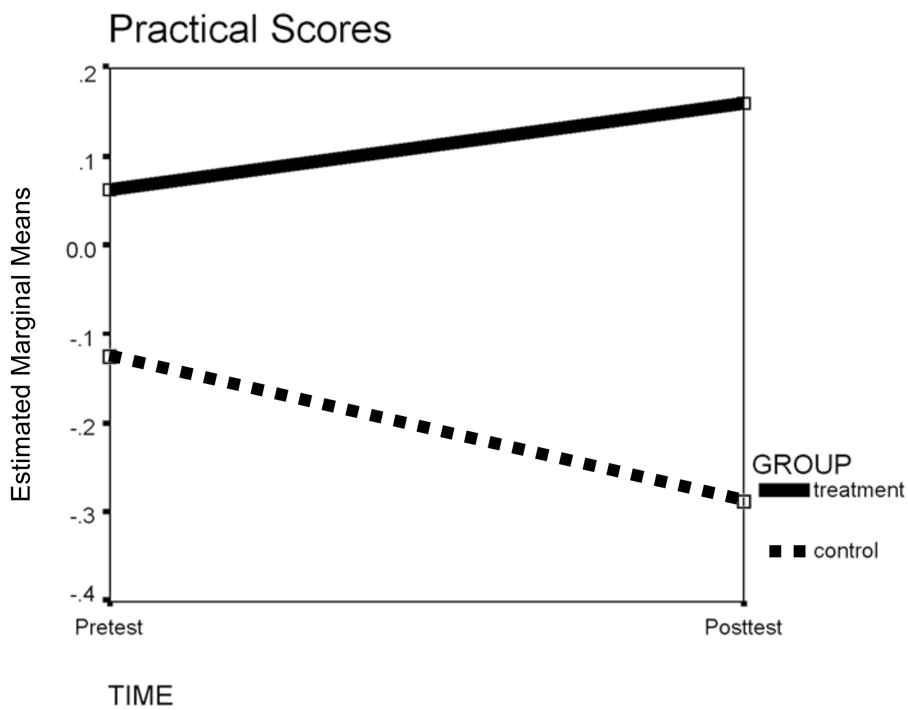


b.



<u>Figure 2.2.</u> Estimated marginal means for memory (a), analytical (b), practical (c), and creative (d) scores.

c.



d.

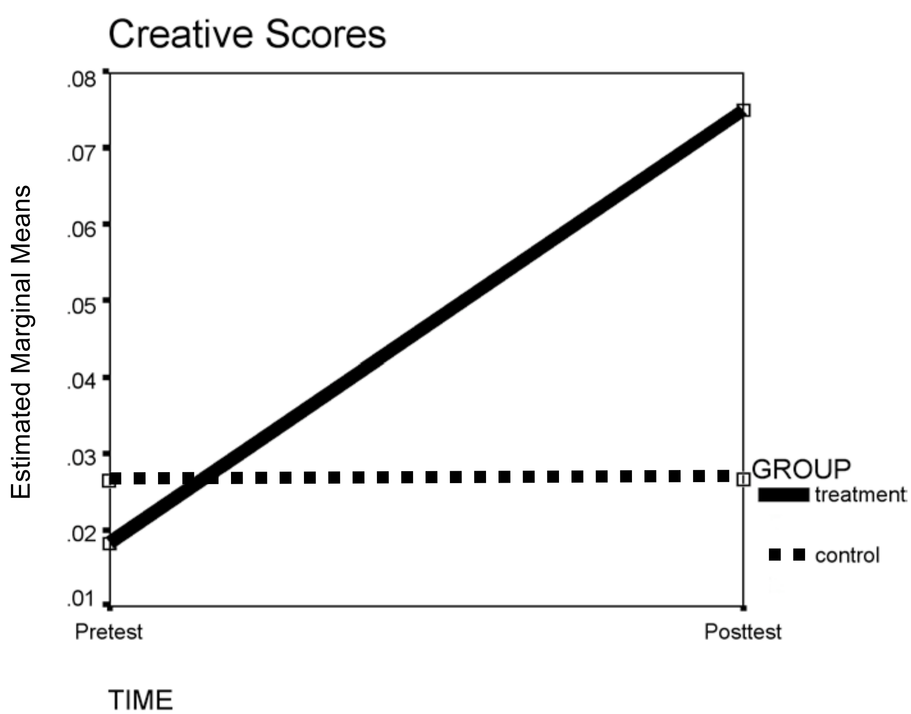


Figure 2.2. Estimated marginal means for memory (a), analytical (b), practical (c), and creative (d) scores (continued).

Our data provide an extension of past data showing that triarchic instruction is superior to conventional instruction across a variety of school subject-matters, participant age levels (primary and secondary), and participant socioeconomic levels. This demonstration shows that teaching analytically, creatively, and practically in a cultural setting rather remote from that of the mainstream United States can make a difference to school achievement, at least if the teaching is adapted to the cultural setting of the individuals, in this case, Yup'ik Eskimos in southwest Alaska. These findings are encouraging because of the ongoing achievement gap between mainstream students and AI/AN populations. However, the results must be viewed cautiously because of the small number of Yup'ik students in this study.

The results are consistent not only with our past instructional data (Sternberg et al., 1998), but also with studies we have done showing that intelligence has somewhat different contextual instantiations in different cultures, and that these instantiations need to be taken into account when considering what it means to be effective in these varied settings (see, e.g., Berry, 1984; Grigorenko et al., 2001; Lipka et al., 1998; Okagaki & Sternberg, 1993; Serpell, 2000; Sternberg & Kaufman, 1998; Sternberg et al., 2001; Yang & Sternberg, 1997). The results of our study suggest that teaching can be made more effective if it takes into account the cultural context in which it is being done, and if it appeals to varied abilities, namely, analytical, creative, and practical ones.

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Endnotes

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[1] The term Alaska Native is used in reference to Alaska's original inhabitants. Alaska Natives include three groups—Aleut, Eskimo, and Indian groups; the groups differ in terms of their ethnic origin, language, and culture.

[2] The size of groups of adolescents to be compared (triples with *N*=3) was determined by previous ethnographic and anthropological observations. The suggested method, however, is applicable to units of comparison of any size (pairs, quadruples, quintuples, etc.)

[3] National Science Foundation award #9618099—*Adapting Yup'ik Elders' Knowledge: PreK-to-sixth grade Math and Instructional Materials*

[4] Since the groups were unequal in size, we explored the applicability of MANOVA for the analysis of these data by performing Box's Test of Equality of Covariance Matrices and Levene's Test for Equality of Error Variance. Both tests were statistically significant ($p<.01$), indicating the presence of inequality in variances across groups. However, close inspection of the data (see Table 2.1) indicates that for two of the four variables, the larger variance is observed in the treatment group (practical and creative), whereas for the other two variables (analytical and memory), larger variance is observed in the control group. Because the results do not show a consistent pattern of large variance in either group, we conclude that the application of MANOVA to these data is adequate.

[5] See endnote. 2. For the posttest indicators, both Box's and Levene's Tests produced nonsignificant *p*-values.

[6] Because the representations of rural and urban communities were so uneven across treatment and control groups, we repeated the series of the analyses described in this section for a subsample of students from rural communities. At the pretest, the MANOVA revealed no significant differences between the two groups at pretest on memory, analytical, practical, and creative indicators (Pillai's Trace $F_{4,51}=1.3, p>.10$). However, there were significant group differences on the univariate ANOVAs for the creative indicators ($F_{1,55}=4.3, p<.05$), indicating the advantage of the control group. The ANOVA for the total pretest scores was significant ($F_{1,55}=4.0, p<.05$) and also indicated the advantage of the control group. This advantage, however, was not observed at the posttest ($F_{1,55}=0.0, p>.10$). The posttest MANOVA was not significant as well (Pillai's Trace $F_{4,51}=2.0, p>.10$), but the control group still overperformed the treatment group on creative indicators ($F_{1,55}=5.2, p<.05$). The repeated measures of variance revealed that, although the treatment group did not significantly overperform the control group at the posttest, it significantly improved its performance in response to intervention (Pillai's Trace $F_{1,54}=5.0, p<.05$, with respective pre and posttest means as follows: $mean_{control}=-.16$ and $mean_{treatment}=-1.54$ and $mean_{control}=-.55$ and $mean_{treatment}=-.61$). Similarly, for memory, analytical, practical, and creative indicators, the treatment group significantly improved from pre-to-posttest (Pillai's Trace $F_{1,54}=5.0, p<.05$). The corresponding means were as follows: (a) memory pre and post, $mean_{control}=-.11$ and $mean_{treatment}=-.42$, $mean_{control}=-.30$ and $mean_{treatment}=-.01$; (b) analytical pre and post, $mean_{control}=.09$ and $mean_{treatment}=-.32$, $mean_{control}=-.14$ and $mean_{treatment}=-.16$; (c) practical pre and post, $mean_{control} = -.03$ and $mean_{treatment} = -.26$, $mean_{control}=-.09$ and $mean_{treatment}=-.08$; and (d) creative pre and post, $mean_{control}=-.11$ and $mean_{treatment}=-.55$, $mean_{control}=-.01$ and $mean_{treatment}=-.35$. However, although these results, in general, are consistent with the results for the whole sample and indicative of the usefulness of the intervention program for rural students, the sample size and large standard deviations requires us to treat these results with great caution. Moreover, although this study randomly assigned teachers and hence students to experimental and control groups, there was a difference in starting points for the rural experimental and rural control group. In fact, the rural control group outscored the rural treatment group on the pretests by a considerable margin (see above). Because of the small sample size, random assignment did not create "equal" rural groups. This is partially explained by the fact that two of the classes in the treatment group with approximately 30 students were the lowest scoring rural groups on Alaska's Benchmark Exam in math. All 30 students scored at the not proficient level while two classes or 16 students in the rural control group had performed substantially better—56% not proficient, 22% below proficient, and 22% proficient. The other 13 students in the control scored at the 78% and 92% at the not proficient level.

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