Assessing Student's Cognitive Content and Process Skills in IEA CIVED: A Cross-country Analysis

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Abstract

This study used a cognitive diagnostic modelling approach to compare the civic education achievement of 14-year-olds from the IEA CIVED assessment across samples of three countries. Four cognitive attributes describing the content and skills were identified underlying the CIVED test items. Based on mastery of each attribute, students of three countries were classified into different four cognitive profiles. Differences among the countries were found in patterns of attribute achievement. Hong Kong students were strong in basic conceptual knowledge, but weak in advanced analyzing and synthesizing skills. The U.S. students were strong in the analyzing and synthesizing skills and deficient in the advanced conceptual knowledge. Evidence from the cognitive profiling supported the hypothesis that basic conceptual knowledge is prerequisite for more advanced conceptual knowledge/reasoning and for skills.

Keywords: *CIVED, cognitive content and processing skills, cognitive diagnostic modelling*

Introduction

There have been calls to make educational assessments more informative about the cognitive processes measured in students. In particular, there is increasing pressure to adapt costly large-scale assessments so that they are informative about students' cognitive strengths and weaknesses in thinking and learning (Leighton & Gierl, 2007; National Research Council, 2001; U.S. Department of Education, 2004). To address these issues, cognitive diagnostic models (CDMs) (Tatsuka, 1983; Junker & Sijtsma 2001; Yan, Mislevy, & Almond, 2003; de la Torre & Douglas, 2004; von Davier, 2007) have been introduced in large-scale educational assessments to facilitate explanation and prediction of students' performance in greater detail than previous work (Giel, Leighton & Hunka, 2007). Theoretically, these models allow researchers to test hypotheses about the nature of students' response processes when they answer assessment items (Zhang & Rupp, 2009). By utilizing such models, one can provide information about skill mastery status along multiple dimensions that can help teachers and students to choose educational interventions (Xu, & von Davier, 2006). Cognitive diagnostic models have been used on large-scale assessment such as TIMSS, PIRLS, NAEP, and TOEFL to obtain information about student cognitive capacity (Chiu & Seo, 2009; Tatsuoka, Corter, & Tatsuoka, 2004; von Davier, 2007; Xu & von Davier, 2008).

In attempts to explain difference in math achievement from a cross-country perspective, Tatsuoka, Corter, & Tatsuoka (2004) employed a cognitive diagnostic model called the Rule Space Model to analyze data from the TIMSS-R, 1999. They decomposed the TIMSS-R

mathematical test scores into 23 specific content knowledge and processing skills, and compared the knowledge and skills across 20 countries. Clear differences among the countries were found in patterns of subskills achievement. More specifically, the results indicated that U.S. students were strong in content and quantitative reading skills, but weak in others, notably geometry. Across the sampled countries, geometry was found to be associated with logical reasoning and other important math thinking skills. Using the same cognitive diagnostic approach, Birenbaum, Tatsuoka, & Yamada (2004) focused on comparisons of mathematic subskills among three countries: Israel, Japan, and the U.S. The results pointed to the superiority of Japanese students in both total test scores and underlying dimensions of the TIMSS test. The U.S. and Israel students demonstrated similar patterns. That is, both of them had relative strength in most content and special skills but had considerable deficiency in math thinking skills such as logic thinking, inductive thinking, and divergent thinking.

The IEA CIVED data set has been not been analyzed for students' underlying performance using cognitive diagnostic approaches, nor have any studies that we are aware of compared differences across countries in this subject area at this microlevel. The field of civic education and the closely assigned field of social studies education in some countries has recently been concerned with matters other than conceptual knowledge among young people. In fact, major recent reference works such as the *Handbook of Research in Social Studies Education* (Levstik & Tyson, 2008), *Sage Handbook of Education for Citizenship and Democracy* (Arthur, Davies & Hahn, 2008), and *Wiley Handbook of Research on Civic Engagement in Youth* (Sherrod, Torney-Purta & Flanagan, 2010) devote very little attention to the specific nature of civic knowledge, concepts or skills acquired in the classroom. The last major book focused on civic knowledge in young people is more than ten years old and reported only on the U.S. National Assessment of Education Progress in Civics (Niemi & Junn, 1998); a search for research on concept learning in the social studies retrieves literature that is nearly thirty years old (McKinney, Larkins, Ford, & Davis, 1983). However, in policy briefs issued in the United States and widely circulated, such as *The Civic Mission of Schools,* as well as in the statements of many educational leaders it is clear that knowledge (for example, of basic facts about the Constitution) is believed to be essential to more advanced forms of knowledge and to civic participation. Recognition of this widespread belief was one of the reasons that the international report of the CIVED study used the total knowledge score as a predictor of likelihood of voting across countries (Torney-Purta, Lehmann, Oswald, & Schulz, 2001).

The last major book on political knowledge in adults, was published fifteen years ago (Delli Carpini & Keeter, 1996), More recently a few researchers have examined adults' political knowledge, which is usually measured with a focus on domestic politics and current events. This includes a study that related political knowledge to general intelligence and political interest in 500 U.S. college students (Hambrick, Meinz, Pink, Pettibone & Oswald, 2010) and Gronlund & Milner's (2006) examination of adult knowledge data from the Comparative Study of Electoral Systems.

Although most would argue that it is very appropriate to focus on a multidimensional

view of the outcomes of civic education and not exclusively on knowledge, studies of conceptual knowledge related to civic education are of great potential value. Before we can understand the processes by which effective learning takes place, information is needed about the patterns and prerequisite that exist in young people's acquisition of civic concepts and skills. This issue has been addressed in mathematics (Tatsuoka, Corter, & Tatsuoka, 2004) and in science (Steedle & Shavelson, 2009), to give just two examples. The purpose of this analysis of the IEA CIVED study's data from the cognitive test is to provide similar information in this content area.

Theoretical Framework

To do this analysis we use one of the cognitive diagnostic models, the general diagnostic model (GDM) (von Davier, 2005). The GDM is an example of a diagnostic assessment approach to analyzing large-scale tests. It has been developed for analyzing latent variables, such as whether or not a student possesses particular pieces of knowledge or cognitive processing skills required in solving a particular problem. Specifically, the GDM can be used to perform multiple classifications of examinees based on their response patterns with respect to skill attributes. The GDM has been applied successfully to large-scale assessments such as NAEP and TOEFL (von Davier, 2005; Xu, & von Davier, 2006, 2008; Hsieh, Xu, & von Davier, 2009). One advantage of the GDM is that it considers the complex sample design issue in large-scale assessment (Hsieh, Xu, & von Davier, 2009), making it an ideal model to study the CIVED assessment. The major contribution of this paper is to see whether there are distinctive patterns of conceptual and skills-based attributes in students by using these modeling approaches.

Methodology

Data Source

Data for this study come from the CIVED Study of 1999, which surveyed 90,000 14-year-olds from 28 countries. The study involved a three-stage, stratified, clustered sample (described by Baldi et al., 2001). Stratified and clustered sampling procedures lose some of the precision associated with true random sampling. However, both procedures are probability-based and therefore are subject to less sampling error than theoretical, purposive, or convenience sampling (Mertens, 2005). Given that the study does not involve a simple random sample, in which all students have an equal chance of selection, sampling weights are applied to account for different probabilities of selection. In the current study, a total of 11,079 14-year-old students from three countries are selected: Australia, Hong Kong, and the United States.

Outcomes explored in this analysis are students' civic content knowledge and interpretive skills which were measured by the IEA Civic Education Study with a 38-item test. Content knowledge questions dealt with conceptual knowledge about political and civic processes in general (not about the governmental system in any one country); interpretive skills questions asked students to interpret political cartoons, a mock election leaflet, and statements of fact and statements of opinion. The IRT scale of the test is set to have an international mean of

100 and a standard deviation of 20. Reliability for the content knowledge scale (Cronbach's alpha) is equal to .85, and the Cronbach's alpha for the interpretive skills is .79. The basic analysis of IEA CIVED indicated that students performed differently on the civic conceptual content items and on the skills items when these were divided into two categories (Torney-Purta, Lehmann, Oswald, & Schulz, 2001). However the items have not been further subdivided.

Analysis

A three-step procedure is employed in the current analysis of students' cognitive processes and skills in the CIVED assessment. The first step is to identify the dimensional structure of students' cognitive content and process skills underlying the 38 items using exploratory factor analysis, and the second step is to identify and describe the cognitive psychological attributes of the dimensions found to underlie the CIVED assessment. At the third step, the GDM is fit to CIVED data, and results are compared across countries.

Finding and Discussion

Cognitive Diagnostic Model Identification

Educational assessments including the CIVED are currently not developed from detailed cognitive models which would allow the application of an a priori model. In an effort to generate a preliminary cognitive model, Exploratory factor analyses (EFA) of the matrix of right/wrong answers were conducted of the dimensionality of the CIVED assessment across the total samples of three countries. Evidence is found for four dimensions (factors with eigenvalues greater than 1).

Based on the EFA results, two domain experts (who had been involved in the development and study of these items since the beginning of the CIVED study in the mid-1990s) identified the four dimensions as four underlying attributes required for an examinee to successfully answer the CIVED knowledge or interpretive skills items. (An attribute is a description of the procedures, skills, processes, strategies, and knowledge that a student must possess to solve a test item.) The attributes in the CIVED test were A1: basic conceptual knowledge, A2: advanced conceptual knowledge and reasoning, A3: reasoning about and analyzing media graphics and material about issues in the media, and A4: reasoning about and analyzing opinion and applying principles in synthesizing factual knowledge. Table 1 presents the descriptions of the four attributes along with sample items for each attribute.

A hypothesized cognitive model of student's cognitive content and process skills in the CIVED study was generated based on the EFA results and experts' judgments (Figure 1). Generally speaking, in the hypothesized model, basic conceptual knowledge is assumed to be necessary for advanced knowledge (i.e. Attribute 2) and for the two skills (i.e. Attribute 3 and 4). In other words, basic concept knowledge is a predominant attribute which is required by all 38 items even though some items are also designed to assess students' higher level skills (i.e. Attribute 2, 3 and 4). Items measuring basic conceptual knowledge included concepts of rights and citizenship in various forms (see Zhang, Torney-Purta, & Barber, 2010).

The designation of these four attributes from CIVED99 is similar to the upcoming ICCS09 distinction between knowledge and reasoning/analysis (Schulz, 2009). Although the CIVED items are not as sophisticated as the ICCS items in these distinctions, our analysis suggests that there is potential to explore cognitive models based on four attributes with the CIVED data. Also, the analysis is more straightforward, since all respondents in CIVED answered all 38 items of the cognitive test (in contrast to ICCS09, which divided a larger number of items into testlets and used matrix sampling).

In the next step, the proposed attributes per item were then used to construct an incidence matrix, Q, for the GDM (Zhang, et al., 2010). Further analysis was conducted using the GDM through the software *mdltm* (von Davier, 2005).

Validation of Cognitive Diagnostic Modeling

Based on the Q-matrix, four attribute mastery probabilities were estimated through GDM for each student in each country. An attribute mastery probability is the conditional probability of mastering each attribute given a student's item responses and items characteristics which were defined through the Q-matrix. In order to further investigate the validity of the attribute list and the Q-matrix, linear regression analyses were conducted to see whether the attribute mastery probabilities can predict student' total scores (overall performance). The squared multiple correlations (R^2 and adjusted R^2) for the entire sample and for each of the three countries are presented in Table 2. All values in the table are considered satisfactory (Birenbaum, Tatsuoka, & Yamada, 2004).

Comparison Between Australia, Hong Kong, and U.S.

Attribute Mastery Probabilities. Descriptive statistics for attribute mastery probability levels are displayed in Table 3. This is a standard first step in analysis such as this. Results show that for each country, more than half of students mastered Attribute 1—the basic conceptual knowledge. Hong Kong had the highest mean (.695) and the smallest dispersion of mastery probability (.460). It indicated that basic conceptual knowledge was relative easier for Hong Kong students, and they were more homogenous in terms of the attribute 1 when compared with students in Australia and the U.S. The Australia had a higher mean than the U.S. (.613 compared to .595). One-way ANOVA yielded a significant effect of country on the mastery probability of Attribute 1 ($F_{2,10076} = 69.507$; $p < .0001$). Post hoc tests indicated that all means were significantly different ($p < .0001$) from each other.

As for Attribute 2, advanced conceptual knowledge and reasoning, Hong Kong had the highest mean (.466) of mastery probability. Australia had a higher mean of mastery probability than the U.S. (.302 compared to .272). One-way ANOVA results showed a significant effect of country on the mastery probability of Attribute 2 ($F_{2,10076} = 284.772$; $p < .0001$). Post hoc tests indicated that all means were significantly different ($p < .0001$) from each other.

As for Attribute 3, skills in reasoning about media, the U.S. had the highest mean (.562)

of mastery probability. Hong Kong had a higher mean of mastery probability than Australia (.548 compared to .511). A significant effect of country on the mastery probability of Attribute 3 was identified through the one-way ANOVA ($F_{2,10076} = 4.26$; $p < .05$). Post hoc tests specified that Australia significantly differed ($p < .05$) from Hong Kong and the U.S. in terms of means. However, mean of Hong Kong was not significantly different from mean of the U.S.

As for Attribute 4, reasoning and analyzing opinion and fact, the U.S. had the highest mean (.603) of mastery probability. Australia had a higher mean of mastery probability than the U.S. (.504 compared to .415). One-way ANOVA ($F_{2,10076} = 175.764$; $p < .0001$) and post hoc tests showed that all means are significantly different ($p < .0001$) from each other.

In general, the easiest attribute for students from Australia and Hong Kong was the basic conceptual knowledge. More than 60% of students across these two countries mastered the attribute. For the U.S. students, the easiest attribute was reasoning about and analyzing opinion and applying principles in synthesizing factual knowledge. The most difficult attribute for the U.S. students was advanced conceptual knowledge and reasoning (i.e. Attribute 2). Only about 27% of students mastered this attribute. Australia students showed a similar pattern. Only about 30% of students mastered Attribute 2. For the Hong Kong students, the most difficult attribute was reasoning and analyzing opinion and applying principles in synthesizing factual knowledge, which appeared to be the opposite of the U.S. students in terms of the difficulty pattern. Slightly less than half of Hong Kong students mastered this attribute.

Attribute Profiles.
One major outcome of cognitive models is a classification of students into different attribute profiles based on which of the attributes they have mastered (defined as answering an average or better probability of attribute mastery, see later elaboration). Actually mastery or non-mastery of a set of attributes cannot be measured directly and therefore must be inferred from the student's pattern of responses to the set of items through the GDM model.

Mean of each attribute in each sample of three countries was used as a cut-off point to classify student as mastery or non-mastery. An attribute mastery probability above the mean was coded as mastery by the student (denoted by 1), and an attribute mastery probability below the mean as non-mastery (denoted by 0). Students were classified according to their mastery of the four composite attributes. A student who has mastered all four attributes was classified as a member of group or profile 1111. A student who has mastered only A1 and A3 was classified as a member of group or profile 1010. In this way, a student's attribute profile was specified. Because the number of attributes is four, there are 16 (2^4) possible attribute profiles that student can demonstrate. Table 2 lists the 16 attribute profiles and the percentage of students falling into each profile in each country, while Figures 2 to 4 group these into categories.

For each country, we have divided these models into four categories with respect to what

they tell us about students' profiles of achievement.

Category 1 (red in Figure 2 to 4) containing the profile 0000, is consistent with the prediction that students need basic concept knowledge in order to have either advanced concepts and the ability to reason about them (attribute 2), media skills (attribute 3) or analytic skills (attribute 4) . This includes about 19 % of the U.S. sample, 22 % of Hong Kong sample, and 16.5% of Australia sample. However, this category is not definitive evidence for what our prediction, i.e., that mastery of basic conceptual knowledge is necessary for success on the other types of items, since these students have succeeded on none of the attributes.

Category 2 (blue in Figure 2), the profile 1111, is likewise not definitive but it is consistent, since these students do have basic concept knowledge along with the other attributes.   This includes about 28% of the U.S. sample, 38% of Hong Kong sample, and 30.4% of Australia sample. Although not relevant to the points being made here, it is interesting that all samples of three countries have this bi-modal pattern (that is a large proportion of students who answer the test very well and a large proportion who achieve very poor scores). See Torney-Purta and Amadeo (2004) for a further discussion of this pattern.

Category 3 (green in Figure 2) includes all the profiles where the individual possesses Attribute 1 *and also* possesses one or more of the other attributes *or* possesses only Attribute 1. For each country, slightly more than 30% of the sample falls into this category. However, the distributions look different. For the *U.S.* students falling into this category, *about half* of them mastered at least one attribute other than the basic conceptual knowledge. Note that the largest numbers of students are found in 1000 (basic conceptual knowledge only, about 13%), 1011 (basic conceptual knowledge and both skills, about 12%), and 1001 basic conceptual knowledge and analytic skills (about 5%). For Australia students, the large majority in this category are in the 1000 profile. However, less than 2% of Australia students who falls into this category mastered at least one attribute other than basic conceptual knowledge. Hong Kong students demonstrated a similar pattern as Australian students. The majority of Hong Kong students in Category 3 belonged to 1000. Only about 8% of Hong Kong students mastered at least one attribute other than basic conceptual knowledge.

Category 4 (yellow in Figure 2) includes all the profiles where the individual *does not possess Attribute 1 but does possess one or more or the other attributes*.   To have low frequencies of students falling into the models within this category is consistent with the model.   *Consistent with the prediction,* less than 9% of Hong Kong students fall into this category. As for the U.S. and Australia students, there are essentially NO students who do not possess basic conceptual knowledge but who do possess advanced conceptual knowledge or conceptual knowledge and either of the two types of skills.   That is, profiles 0100, 0110, 0101, and 0111 have less than 1% of the sample in them (most of them are actually 0). This indicates that for the US and Australia students, basic conceptual knowledge appears to be essential for advanced conceptual knowledge. *Inconsistent with the overall prediction*, however, 14% of the U.S. sample falls into profile 0011, meaning that they possess the skills (attributes 3 and 4) but neither type of conceptual knowledge.   Another 4% is in 0010 and

2% in 0001 (with neither type of conceptual knowledge but at least one type of skill). Australia students show a similar pattern in that about 17% students fall into 0011, and another 1.4% is in 0010 and 1% is in 0001. One interpretation is that in the United States and Australia, some students may be acquiring "civic skills" that are disconnected from the basic conceptual knowledge in the civic domain that we think of as foundational. They have learned to read newspaper articles, to interpret cartoons or to distinguish between facts and opinions in general rather than as related to social studies and civic concepts.

In summary, there is some evidence that basic conceptual knowledge is a prerequisite for more advanced conceptual knowledge/reasoning and for skills. This can provide useful information supplementing analysis of these three countries by Kennedy, Hahn and Lee (2007) and for future analysis of the process of civic learning.

Conclusion and Implication

This analysis suggests the value of looking beyond the mean scores of different countries at the patterns of students' performance according to underlying cognitive attributes. In the United States we have been able to look at some of the correlates of these profiles in the teacher data (Zhang, et al., 2010). In the future we plan to replicate these analyses for Australia and Hong Kong (and perhaps add other countries).

We also intend to pursue the possible sources outside of social studies and civic education classrooms of the acquisition of civic skills (attributes 3 and 4). Are the students who acquire these skills without conceptual knowledge those who discuss political matters with their parents at home or watch a lot of television news? We intend to replicate the analysis in this paper in several other CIVED countries (including some with patterns which we expect to differ from the three countries already studied) and, if possible, in the ICCS data.

References:

Baldi, S., Perie, M., Skidmore, D., Greenberg, E., Hahn, C., & Nelson, D. (2001). W*hat Democracy Means to Ninth-graders: U.S. Results from the International IEA CivicEducation Study.* Washington, DC: U.S. National Center for Education Statistics.

Birenbaum, M., Tatsuoka, C. & Yamada, T. (2004). Diagnostic assessment in TIMSS-R: Between-countries and within-country comparisons of eighth graders mathematics performance. *Studies in Educational Evaluation, 30*, 151-173.

Chiu, C. & Seo, M. (2009). Cluster analysis for cognitive diagnosis : An application to the 2001 PIRLS reading assessment. *IERI Monograph Series: Issues and Methodologies in Large-scale Assessment, 2,* 137-159.

Arthur, J., Davies, I. & Hahn, C. (2008). *Sage handbook for citizenship and democracy.* Los Angeles: Sage.

de la Torre, J., & Douglas, J. A. (2004). Higher-order latent trait models for cognitive diagnosis. *Psychometrika, 69*, 333-353.

Delli Carpini, M. & Keeter, S. (1996). *What American know about politics and why it matters.* New Haven: Yale University Press.

Gronlund, K. & Milner, H. (2006). The determinants of political knowledge in comparative perspective. *Scandinavian Political Studies, 29(4),* 386-406.

Junker, B. W., & Sijtsma, K. (2001). Cognitive assessment models with few assumptions, and connections with nonparametric item response theory. *Applied Psychological Measurement, 25*(3), 258-272.

Hambrick, D., Meniz, E., Pink, J, Pettibone, J., & Oswald, F. (2010). Learning outside the laboratory: Ability and non-ability influences on acquiring political knowledge. *Learning and Individual Differences, 20,* 40-45.

Hsieh, C., Xu, X. & von Davier (2009). Variance estimatino for NAEP data using a comprehensive resampling-based approach: An application of cognitive diagnostic models. *IERI Monograph Series: Issues and Methodologies in Large-scale Assessment, 2,* 161-173.

Kennedy, K., Hahn, C. & Lee, W. O. (2007). Constructing citizenship: Comparing the views of students in Australia, Hong Kong and the United States. *Comparative Education Review, 52(1),* 53-91.

Leighton, J., & Gierl, M. (2007). *Cognitive diagnostic assessment for education: Theory and applications.* New York, NY: Cambridge University Press.

Levstik, L. & Tyson, C. (2008). *Handbook of research in social studies education.* New York: Routledge.

McKinney, C. W., Larkins, A. G., Ford, M. J., Davis, J. (1983). The effectiveness of three methods of teaching social studies concepts to fourth-grade students. *American Educational Research Journal, 20(4),* 663-670.

National Research Council. (2001). *Knowing what students know: The science and design of educational assessment.* Washington, DC: National Academy Press.

Niemi, R. & Junn, J. (1998). *Civic education: What makes students learn.* New Haven: Yale University Press.

Schulz, W. (2009). Questionnaire construct validation in the international civic and citizenship education study. *IERI Monograph Series: Issues and Methodologies in*

Large-scale Assessment, 2, 113-135.

Sherrod, L, Torney-Purta, J. & Flanagan, C. (2010). *Handbook of research on civic engagement in youth.* Hoboken, NJ: John Wiley and Sons.

Steedle, J. & Shavelson, R. (2009). Supporting valid interpretations of learning progression level diagnoses. *Journal of Research in Science Teaching, 46(6),* 699-715,

Tatsuoka, K. K. (1983). Rule-space: An approach for dealing with misconceptions based on item response theory. *Journal of Educational Measurement, 20,* 345-354.

Tatsuoka, K. (1985). A probabilistic model for diagnosing misconceptions in the pattern classification approach. *Journal of Educational Statistics, 12*, 55-73.

Tatsuoka, K., Corter, J., & Tatuoka, C. (2004). Patterns of diagnosed mathematical content an process skills in TIMSS-R across a sample of 20 countries. *American Educational Research Journal, 41*(4), 901-926.

Torney-Purta, J. & Amadeo, J.-A. (2004). *Strengthening democracy in the Americas through civic education.* Washington, D.C.: Organization of American States.

Torney-Purta, J.; Lehmann, R.; Oswald, H.; Schulz, W. (2001). *Citizenship and education in twenty-eight countries: civic knowledge and engagement at age fourteen.* Amsterdam, IEA. Web address: www.terpconnect.umd.edu/~iea/.

U.S. Department of Education. (2004, September 16). Strong accountability: Testing for results: Helping families, schools, and communities understand and improve student achievement. Retrieve Februry 15, 2006, from http://www.ed.gov/nclb/accountablity/ayp/testingforresults.html

von Davier, M. (2005). A general diagnostic model applied to language testing data (ETS Research Rep. No. RR-05-16). Princeton, NJ: ETS.

von Davier, M. (2007). *Hierarchical general diagnostic model* (Research Report No. RR-07-19). Princeton, NJ: Educational Testing Service.

Xu, X., & von Davier, M. (2006). General diagnosis for NAEP proficiency data (ETS Research Rep. No. RR-06-08). Princeton, NJ: Educational Testing Service.

Xu, X., & von Davier, M. (2008). *Fitting the structured general diagnostic model to NAEP data* (Research Report No. 08-27). Princeton, NJ: Educational Testing Service.

Yan, D., Mislevy, R. J., & Almond, R. G. (2003). *Design and analysis in cognitive assessment* (ETS Research Rep. No. ETS RR-03-32). Princeton, NJ: Educational Testing Service.

Zhang, T., Rupp, A. A. (2009). *Assessing the model fit of cognitive diagnosis models through Bayesian methods: A simulation study.* Paper presented at the annual meeting of the National Council on Measurement in Education (NCME), San Diego, CA.

Zhang, T., Torney-Purta, J. V. & Barber, C.(2010, May). *Teacher qualifications and student's cognitive content and process skills in Civic Education: A multilevel analysis.* Paper presented at the annual meeting of the American Educational Research Association (AERA), Denver, CO.

Tables and Figures

Table 1.

Sample Items and Knowledge, Skill, and Process Attributes to Explain Performance on CIVED Assessment (1999)

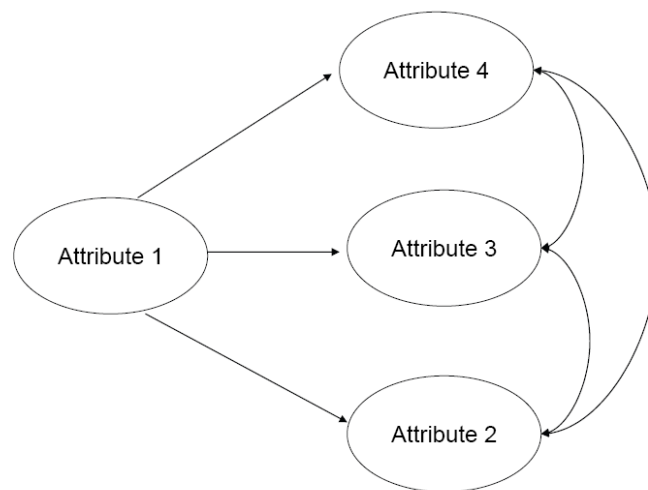|	
Attribute 1: Basic conceptual knowledge	
Item 1	Citizen
2	Laws
3	Political right
Attribute 2: Conceptual knowledge and reasoning	
Item 8	Trade unions
15	Violation/rights
17	Government non-democratic
Attribute 3: Reasoning about and analyzing media graphics and material about issues in the media	
Item 5	Discrimination
14	Cartoon/democracy
23	Election leaflet
Attribute 4: Reasoning and analyzing opinion and applying principles in synthesizing factual knowledge	
Item 12	Who governs
20	Children's rights
38	Fact/opinion

Figure 1. A hypothesized cognitive model of student's cognitive content and process skills in CIVED study

Table 2.

R^2 and Adjusted R^2 for Predicting the Total Scores from the Attribute Probabilities

Sample	N	R^2	adjusted R^2
Australia	3301	0.854	0.854
Hong Kong	4992	0.856	0.856
U.S.	2786	0.862	0.861
Total	11079	0.850	0.850

Table 3.

Means, Standard Deviations and Correlation Matrix for the Four Attributes

Sample	Attribute	Mean	SD
AUS	A1	0.613	0.487
	A2	0.302	0.459
	A3	0.511	0.500
	A4	0.504	0.500
HK	A1	0.695	0.460
	A2	0.466	0.499
	A3	0.548	0.498
	A4	0.415	0.493
U.S.	A1	0.595	0.491
	A2	0.272	0.445
	A3	0.562	0.496
	A4	0.603	0.489

Table 4

Sixteen Attribute Profiles Across Countries

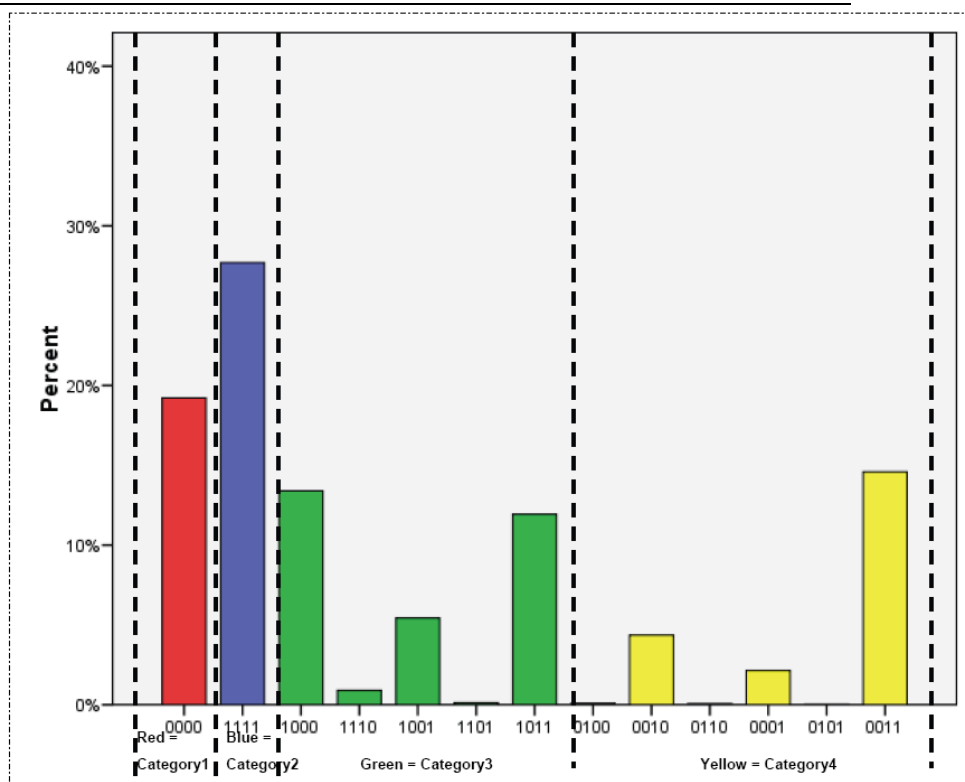| Attribute				Proportion of examinees		
A1	A2	A3	A4	U.S.	Australia	HK
0	0	0	0	19.2%	16.5%	22.1%
1	0	0	0	13.4%	31.5%	23.9%
0	1	0	0	0.1%	0.0%	1.3%
1	1	0	0	0.0%	0.0%	0.3%
0	0	1	0	4.4%	1.4%	1.2%
1	0	1	0	0.0%	0.0%	2.8%
0	1	1	0	0.1%	0.6%	2.4%
1	1	1	0	0.9%	0.0%	3.5%
0	0	0	1	2.1%	1.0%	0.2%
1	0	0	1	5.4%	0.0%	0.0%
0	1	0	1	0.0%	0.0%	0.0%
1	1	0	1	0.1%	0.1%	0.0%
0	0	1	1	14.6%	16.9%	2.0%
1	0	1	1	11.9%	1.0%	1.1%
0	1	1	1	0.0%	0.8%	1.2%
1	1	1	1	27.7%	30.4%	38.0%

Figure 2. U.S. Sample: Four categories, and percentage distribution of examinees in 16 attribute profiles. [Only profiles where at least .1% of the students were found are included; see previous table for those with 0%].
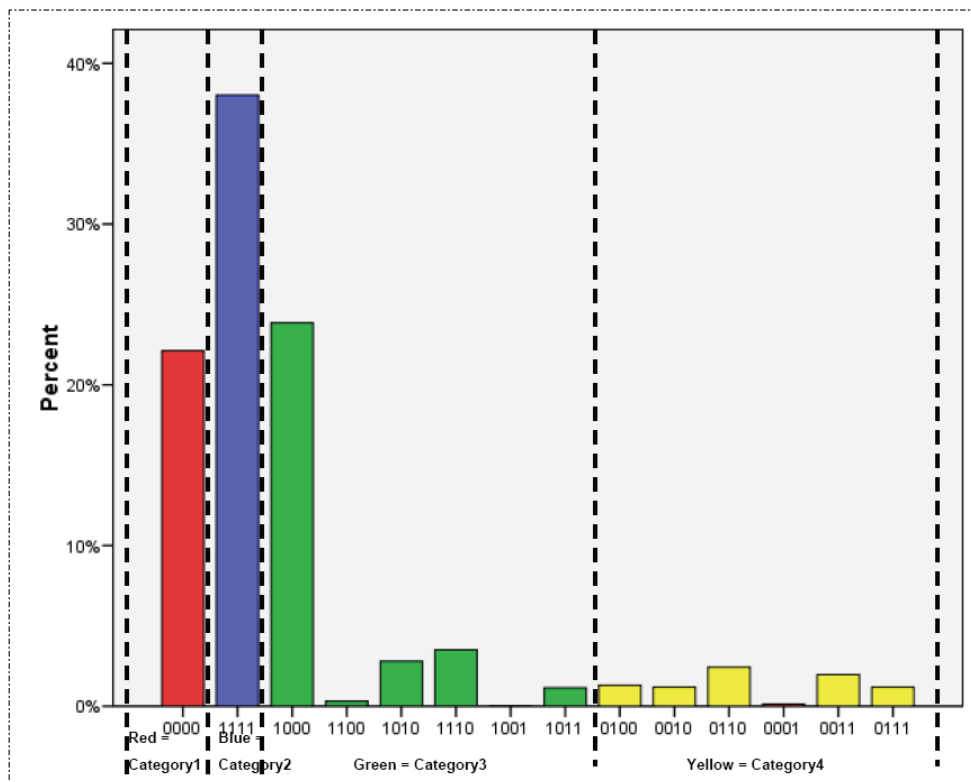
Figure 3. Hong Kong Sample: Four categories, and percentage distribution of examinees in 16 attribute profiles. [Only profiles where at least .1% of the students were found are included; see previous table for those with 0%].
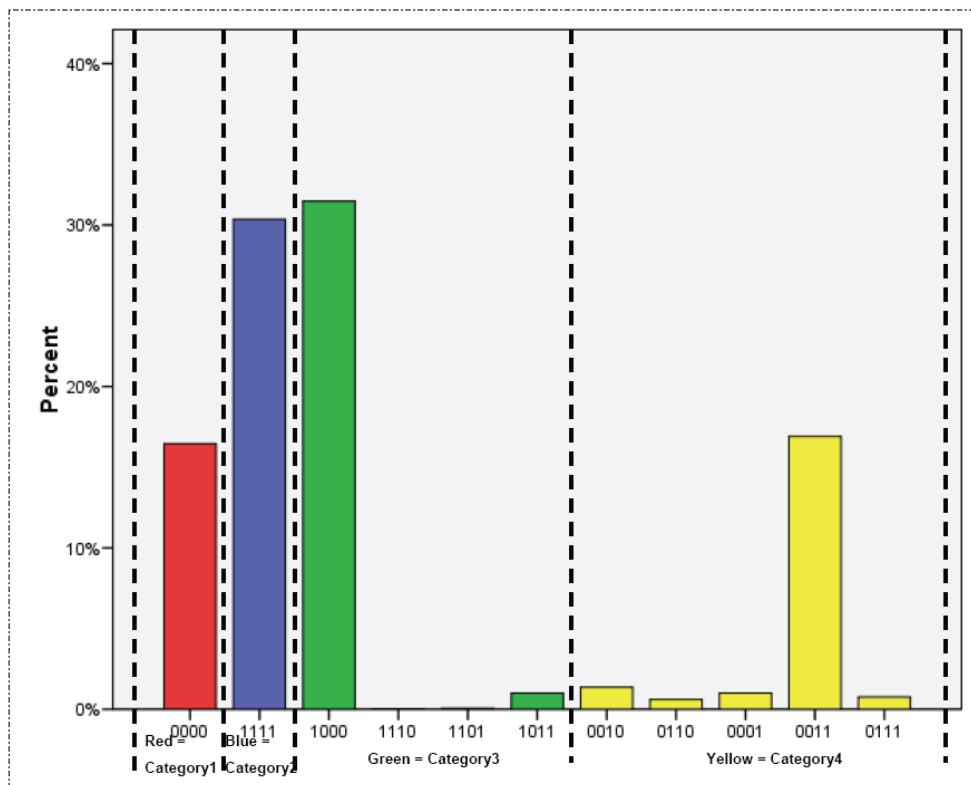

Figure 4. Australia Sample: Four categories, and percentage distribution of examinees in 16 attribute profiles. [Only profiles where at least .1% of the students were found are included; see previous table for those with 0%].