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THE DEVELOPMENT OF A SELECT-AND-FILL-IN CONCEPT MAP ASSESSMENT OF HUMAN GEOGRAPHY KNOWLEDGE

Stephanie Wehry, Heather Monroe-Ossi, Rebecca England, & Cheryl Fountain, Florida Institute of Education at the University of North Florida, Jacksonville, Fl, USA

Email: swehry @unf.edu

Abstract. The purpose of this paper is to report the decision process in choosing a concept mapping task to assess the human geography knowledge of middle school students participating in an after-school college reach-out program, Pre-Collegiate Connections Program. Research is presented supporting construct-a-map and fill-in concept mapping tasks. The final map, a select-and-fill-in task, was developed and field-tested with 43 students during the first week of May 2010. Analyses indicated that, across all three grades, the omitted concepts were moderately difficult and exhibited a Cronbach's alpha of .84.

1 Introduction

The overall purpose of this project was to develop a measure of the human geography knowledge of middle school students participating in an after-school college reach-out program, Pre-Collegiate Connections Program (P-CCP). P-CCP was first implemented during the 2007-2008 academic year. The participating students attended two low-performing middle schools in the urban core of a large American city located in a southeastern state. During the first year, the content of the program was designed for and offered to sixth graders. Seventh-grade content was designed, and P-CCP was offered to sixth and seventh graders during the 2008-2009 academic year. By the third year of implementation, the 2009-2010 academic year, design work was complete, and P-CCP was fully implemented across all three middle school grades.

At each grade, the academic content of P-CCP is focused on human geography. This choice was motivated by the offering of AP Human Geography in the ninth grade in all district high schools. Thus, a P-CCP goal is to help students develop the core content knowledge of human geography in hopes that this will motivate participants to enroll in and subsequently to be successful in AP Human Geography. P-CCP developers see meeting this goal as a major indicator of successful efforts toward ensuring that P-CCP participants see themselves as college bound students.

Students are eligible to participate in P-CCP based on a combination of several factors including below grade-level achievement on the state reading and/or mathematics accountability measures; poverty-status determined by eligibility for the Free and Reduced Lunch Program, funded through the National School Lunch Act; and /or the potential for being a member of the first generation in their family to attend and complete college. During the 2009-2010 academic year 74, 70, and 58 students participated in the sixth-, seventh-, and eighth-grade P-CCP initiative, respectively.

Two aspects of the P-CCP curriculum effected our decision to field test a concept mapping evaluation of participants' knowledge of the 3-year P-CCP human geography curriculum content. The first aspect is that the P-CCP curriculum was developed using a backward design process (Wiggins & McTighe, 2005). The backward design process provides a detailed table of specification describing curriculum goals, and the table was available to the assessment developers. Second, concept mapping was used as an instructional strategy in all three grades of implementation. Thus, the use of concept mapping assessments would not require providing concept mapping training to the students prior to the assessment.

2 Using Concept Mapping for Assessment

Concept mapping has long been seen as a powerful tool to promote meaningful learning (e.g., Kinchin, 2000; Kinchin

& Hay, 2000; Novak, 1990; Novak, 1998; Novak & Cañas, 2008; Novak & Gowin, 1984). Four primary uses for concept mapping were suggested by Novak: for learning, instruction, planning, and assessment (1990). However, the use of concept mapping for assessment has not been as popular as its use for instruction (see Broers, 2009; Kinchin, 2000; Ruiz-Primo & Shavelson, 1996). When concept mapping tasks are used for assessment, the purpose is most often to measure the mapper's knowledge structures and validity studies have generally addressed this purpose. However, for those interested in using concept mapping for assessments, decisions need to be made about the three assessment-related facets of a concept mapping framework developed by Ruiz-Primo and Shavelson as well as potential trade-offs between efficiency and validity resulting from the decisions.

The proposed assessment-related framework describes concept map production as the interrelationship of three map facets: task for the respondent, format of the response, and a scoring system that produces reliable and valid results (Ruiz-Primo & Shavelson, 1996). The gold standard is student-generated concept maps that involve no constraints; however, as pointed out by several researchers (see Broers, 2009; Yin,Vanides, Ruiz-Primo, Ayaly, & Shavelson 2005), unconstrained student-generated maps can be idiosyncratic. Ruiz-Primo and Shavelson described three ways the concept mapping task draws out students' knowledge: task demands, task constraints, and task structure. Task demands for students range from the heavy cognitive demand of student-generated concept map formats to the more moderate demands of fill-in type concept map formats. Task constraints involve restrictions imposed on the task. For instance, students may be supplied a list of concept to use, asked to construct an hierarchical map, supplied a list of linking phrases, or provided a map structure to fill in. The structure of the task results from combining the task demands and the constraints.

Numerous scoring systems have been proposed and studied, with most systems building on the work of Novak and Gowin (1984) in which the number of propositions, cross-links, and the concept maps' hierarchical structures receive scores. McClure and Bell (1990) studied six scoring methods involving holistic, rational, and structural scoring used alone and in conjunction with a master map. Ruiz-Primo and Shavelson (1996) provided a detailed list of scoring systems available at that time. West, Park, Pomeroy and Sandoval (2002) studied structural and relational scoring systems. Kinchin (2000) and Kinchin and Hays (2000) suggested a two-tier system that provides a qualitative approach assessing the overall map structure (chain, spoke, and net) as well as the structural features. Leake, Maguitman, & Reichherzer (2004) proposed a scoring system to quantify the importance of concepts by measuring the number of links going into and out of concepts nodes. However, at this point, there is no universally recommended scoring system, and researchers continue to develop and study scoring systems in efforts to better measure the structure of knowledge and to automate the use of developed scoring systems.

2.1 Studies by Ruiz-Primo and Her Colleagues

Concept mapping tasks that constrain students' construct-a-map task by providing a list of concepts and fill-in concept mapping tasks that constrain students by providing combinations of map structure, concepts, and linking phrases are important to P-CCP decisions. Ruiz-Primo, Schultz, Li, and Shavelson (2001) studied the validity of three types of maps frequently used for assessing science achievement: construct-a-map with a concept list provided; fill-in-concept maps with a list of omitted concepts, in-place concepts, linking phrases, and map structure provided; and fill-in-linking phrases maps with a list of omitted linking phrases, in-place linking phrases, concepts, and concept map task with map structure provided. Research participants were high school chemistry students. The construct-a-map task was not constrained in any manner other than the provision of 20 concepts. Analyses resulted in two findings relevant to P-CCP decisions. First, fill-in-concept and fill-in-linking phrase maps are not equivalent measures. Students generally found fill-in-linking phrases to be more difficult. Second, construct-a-map tasks better reflect differences among students' knowledge.

Ruiz-Primo, Shavelson, Li, and Schultz (2001) used think-aloud techniques to gain insight into the cognitive activities that high school chemistry students used relative to performance on the concept mapping tasks. Construct-a-map responders used slightly more explanation activities (39.1%) than monitoring activities (28.2%). Fill-in map responders used more monitoring activities (40.9%) than explanation activities (4.6%). Explanation activities were described as defining the response by providing relative details, comparing and contrasting information, and justifying responses. Monitoring activities were described as the application of a strategy for performing the task, use of effective reflection that acknowledged a problem and formed a solution, use of ineffective reflection that acknowledged a problem but offered no solution, use of self-checking, and use of reviewing the task performance for accuracy.

Students completing fill-in concept map tasks were more aware of accuracy than when completing construct-a-map tasks. Thus, researchers concluded that the low-constrained construct-a-map tasks allow students more opportunity to use conceptual knowledge to complete the task while more-constrained fill-in maps encourage students to closely monitor the accuracy of their responses.

Concept mapping tasks were also evaluated across proficiency groups which included concept maps produced by teachers, low-performing students, and high-performing students. Ruiz-Primo, Shavelson, et al. (2001) reported that a higher percentage of low-performing students used monitoring activities than high-performing students, and that when low-performing students completed construct-a-map tasks, think-aloud techniques revealed "The low-performing student read all the concepts, selected one with no apparent justification for doing so, and started drawing the map" (p. 125).

The work of Ruiz-Primo, Shavelson, et al. (2001) indicated that fill-in map formats may not measure the same construct as construct-a-map formats; however, we were equally concerned about their finding that low-performing high school chemistry students may not be up to the cognitive demand of construct-a-map formats. All of the P-CCP participants attend low-performing middle schools and are most likely performing below grade-level on one or more of the state's accountability measures. Thus, we questioned whether the construct-a-map task would reflect P-CCP students' human geography knowledge.

2.2 Studies by Schau and Her Colleague

Schau and her colleagues (Schau & Mattern, 1997; Schau, Mattern, Zeilik, Teague, & Weber, 2001) also studied the use of the fill-in concept map format for assessments because they believed that while construct-a-map tasks could be useful for classroom assessments of connected learning, that construct-a-map tasks have limitations. These limitations include the lack of a universally accepted scoring system, the amount of time required to complete the task, proficiency of concept mapping skills required for students to perform the task, and the imposition of high levels of cognitive demand on the responding students (Schau & Mattern, 1997). P-CCP students are rarely described as high performing; therefore, a concern is that, in Schau and Mattern's view, the cognitive demand of construct-a map may be more problematic for low-performing students

Schau et al. (2001) provided detailed research on the development and use of fill-in concept map formats with middle school science students and undergraduate students enrolled in an introductory astronomy course. The development of fill-in maps and their relationship to multiple choice tests that measure the same constructs is relevant to the P-CCP study. Schau et al. developed a variety of fill-in type maps (22 in all) and then evaluated the types with middle school science students. A non-exhaustive list of studied formats included a variety of response formats such as, which elements were omitted (concepts or linking phrases), how many elements were omitted, and the relative placement of the omitted elements. Results of their evaluation narrowed the list of 22 fill-in map types to two formats with non-consecutive concepts omitted. Think alouds, conducted with 12 students, revealed two important outcomes: students accepted the task and no differences were detected in how students approached the concept mapping task when the response format was a paper and pencil task or involved the manipulation of movable pieces.

The concept mapping format that was subsequently studied was a select-and-fill-in (SAFI) concept map with up to 50% of the non-consecutive concepts removed. Field testing resulted in a final version with 36% (38) of the 105 concepts removed. Scores on this SAFI concept map, reflecting the percent of correct responses, were compared to a 27-item multiple choice test. Cronbach's alpha for the SAFI was .94 and for the multiple choice .85. The instruments were tested across seventh- and eighth-grade science students with differential expectations for outcomes. Results indicated that, on average, eighth graders scored 66% correct and seventh graders scored 58% correct. This pattern matched that obtained using the multiple choice tests.

3 Decision to Use SAFI Concept Maps to Assess Human Geography Knowledge

After reviewing the work of Ruiz-Primo and her colleagues (Ruiz-Primo & Shavelson, 1996; Ruiz-Primo, Shavelson, et al., 2001; Ruiz-Primo, Schultz, et al. 2001) and Schau and her colleagues (Schau & Mattern, 1997; Schau et al., 2001), we decided to develop a SAFI concept map similar to the one developed and tested by Schau et al. Several factors influenced our decision. We agreed with Schau and Mattern that the task in student-generated concept maps could potentially place a high cognitive demand on low-achieving students. Ruiz-Primo, Shavelson, et al. reported think aloud findings indicating that low-performing students did not develop strategies to complete construct-a-map tasks rather they began the task seemingly at random. We also think that the use of monitoring activities in performing fill-in concept mapping tasks is a positive outcome especially when the activities lead to effective reflection, checking, and developing task completion strategies.

We were further influenced by the work of Schau et al. (2001). Their first reported study involved middle school students and included some students similar to P-CCP students. We believe that it is important that the studied middle school students accepted the task; moreover, the fact that some even enjoyed the concept mapping task was impressive. P-CCP students have had numerous experiences with testing as part of high-stakes, accountability assessments, and the students have not necessarily enjoyed positive outcomes. Furthermore, P-CCP participation is entirely voluntary, and students frequently choose P-CCP participation over competing, less academically focused after-school programs. Thus, it is in everyone's best interest that we evaluate P-CCP human geography knowledge with novel methods that students see as a pleasant activity rather than as just another high-stakes assessment. We plan to use the developed instrument across all implementation grades; therefore, we expect differentiated outcomes. At this time, however, in deference to Ruiz-Primo, Shavelson, et al. (2001), we refrain from suggesting that we are measuring the human geography knowledge structure of the P-CCP students.

4 Development of the P-CCP Human Geography SAFI Map

SAFI formats are created in two steps; the first is the creation of a master map by an expert, often the teacher. Then, the expert omits some or all of the concepts or linking phrases. Students are then asked to fill-in what is omitted by selecting from a list of provided concepts (Schau & Mattern, 1997).

The design of the P-CCP curriculum resulted in the creation of a table of specification for each grade. The first step in master concept map creation was to locate all of the concepts in the table of specification for each grade. Table 1 shows the resulting list of identified concepts. In looking at the table of concepts, it became obvious that the curriculum was designed from the bottom-up starting at the sixth grade with self, family, and neighborhood. By the eighth grade, the curriculum had expanded to the more global concepts of nation states. The identified concepts led to internal discussions of the big ideas of human geography—the big ideas that form the first levels of a top-down hierarchical map and that are missing from the concepts listed in Table 1.

The research team collectively realized that they did not have the human geography expertise to place a reasonable number of the concepts listed in Table 1 in an expert P-CCP human geography concept map—especially one that would encompass all three grades. The resulting concept map would map the top-down hierarchy of human geography and include the Table 1 concepts. At this point, a human geography expert from the Economics Department at a local university agreed to join the research team to assist in the creation of the expert map. After lengthy discussions of the concept list and armed with The Cultural Landscape: An Introduction to Human Geography-Tenth Edition, (Rubenstein, 2011), a first draft of an expert concept map was completed. The first attempt at constructing the expert concept map incorporated the discussions with the human geography expert by adding the big ideas using generic terms that the P-CCP students would understand. The final SAFI concept map, shown in Figure 2, was agreed upon by the human geography expert and the P-CCP implementation team. The SAFI concept map contained 72 concepts, some of which are not included in Table 1 and some concepts listed in Table 1 were not included on the SAFI concept map.

The final SAFI concept map, omitting 20 concepts, is shown in Figure 2—the omitted concepts are shown in Figure 1. In keeping with the SAFI concept map developed by Schau et al. (2001), consecutive concepts were not removed in the human geography SAFI concept map. Thus, most of the omitted concepts are at the bottom of the map (lower in the hierarchy).

5 Field Testing the P-CCP Human Geography SAFI Map

During the first week of May 2010, 43 P-CCP students agreed to field test the SAFI by completing the puzzle as part of their routine after-school activities. The sample of 29 girls and 14 boys included 23, 13, and 7 sixth-, seventh- and eighth graders, respectively. Student responses, coded 1 for correct responses and 0 for incorrect responses) were analyzed to determine item (omitted concept) difficulty, item differentiation by grade, differentiation by gender, and Cronbach's alpha. Results of the analyses are presented in Table 2.

When all omitted concepts are considered across all grades, the SAFI exhibited an acceptable coefficient of internal consistency, .84, and only one concept (outside influences from the sixth-grade curriculum) was difficult with an estimated mean of .279. However, more than 90% of the students correctly used three of the omitted concepts (two from the seventh-grade and one from the eighth grade curriculum). In looking at the difficulty of omitted concepts across gender, 90% of the boys correctly used five omitted concepts and 90% of the girls correctly used three. Two omitted concepts from the sixth-grade curriculum presented difficulty for the boys. Cronbach's alpha calculated for boys and girls was nearly the same at .85 for boys and .84 for girls. A slightly different picture emerged when SAFI concepts were analyzed for each grade. The sixth-graders struggled with concepts from the sixth-grade curriculum while they found concepts from the seventh- and eighth-grade curricula easy. In fact, Cronbach's alpha for the four sixth-grade omitted concepts was an unacceptable .36. The seventh-graders somewhat struggled with the sixth-grade omitted concepts but they found the difficulty of most of the seventh-grade curriculum omitted concepts reasonable. Moreover, Cronbach's alpha for the 10 seventh-grade curriculum omitted concepts was .83 which is close to the value for all 20 items. All eighth-graders correctly used four omitted concepts, two from the seventh-grade curriculum and two from the eighth-grade curriculum. Cronbach's alpha for the 7 eighth-grade curriculum omitted concepts was .73 which could be improved, but is acceptable.

Eighth Grade	Seventh Grade	Sixth Grade
Sovereignty	**Jacksonville**	Productive teams
Personal choices	**Beaches**	Emotions
Nation-states (Countries)	**Rivers**	**Behaviors**
Interdependence	**Flatlands**	Future
Domino theory	**Marsh lands**	**Goals**
Developing countries	**Forests**	**Barriers**
Socioeconomic welfare	**Local government**	Likes/dislikes
Economic development (Production)	**Mayor**	Strengths/weaknesses
Gross Domestic Product	**City council members**	Follow through/problem solving
Underdeveloped countries	**Judges**	Life experiences
Birth rate	**Representatives**	**Outside influences**
Death rate	**Revenue**	Personal characteristics
Life expectancy	**Flora**	**Expectations**
Political instability	**Fauna**	Communication
Disease	Indigenous	Social skills
Push factors	**St. Johns River**	**Historical events**
Pull factors	Settlers (Jacksonville)	**Family traditions**
Landmarks	**Migrate**	Genealogy
Cultural significance	**Economic activities (production)**	**Neighborhood**
Governmental practices	Geography	Map features
Resources	**State government**	Map production
Symbolism	Spanish explorers	Community well-being
Flag	**St. Augustine**	School well-being
National Anthem	**Tourism**	**Migration**
Environment	Jobs	James Weldon Johnson
Depletions of Natural Resources	Tax base	**Compass Rose**
Pollutions	Northern transplants	**Self concept**
Conflicts	**Immigrant laborers**	
United Nations	Refugees	
United Nations Headquarters	**Physical characteristics (geographic regions)**	
International peace	**Man-made characteristics**	
Security	Political parties	
United Nations Organs (6)	**Distributions of resources**	
	Carbon	
	Atmosphere	
	Landmark (man-made and natural)	
	Memorable sites	
	Travel	

Table 1. P-CCP Human Geography Concepts by Grade

Note. Bold-faced concepts in Table 1 represent concepts that developers included in the SAFI concept map in Figure 2. When language differed from the table of specification, those differences represent concepts of importance, big ideas, to the field of human geography content. SAFI developers attempted to use both the language of Rubenstein (2011) and the curriculum table of specifications in labeling the concepts.

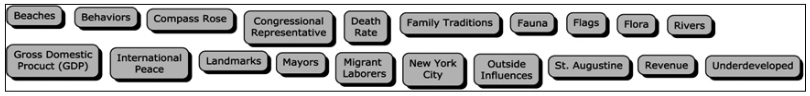

Figure 1. Omitted concept bank

Note. The Figure presents the list of 20 concepts for students to use to fill-in the omitted concepts indicated on the concept map in Figure 2. Students are to use all concepts and to use each concept only once.

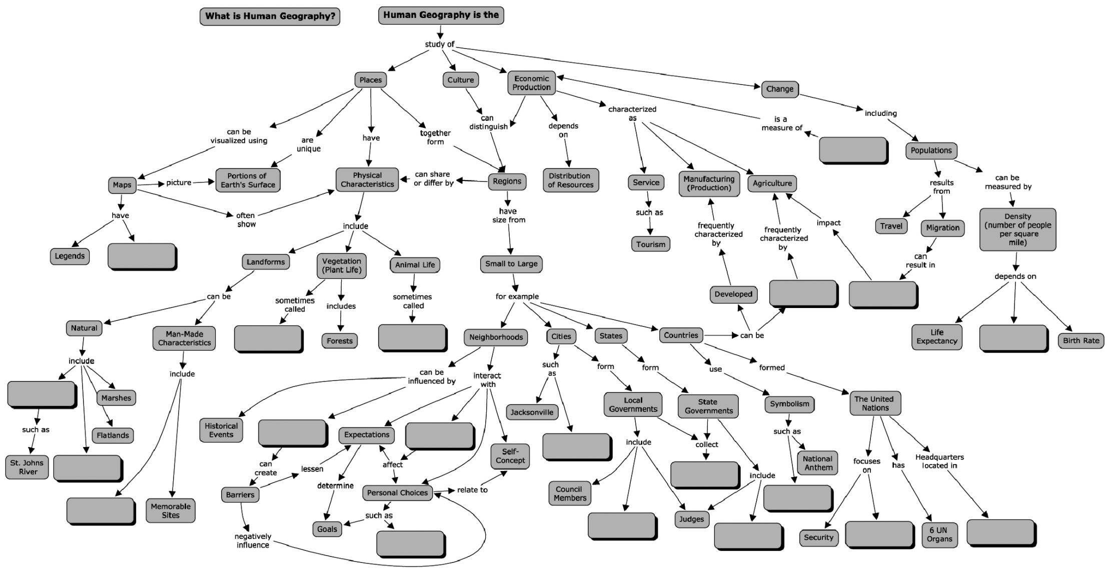

Figure 2. SAFI human geography concept map

	Item grade	Mean all	6th	7th	8th	Males	Females
Items							
Compass Rose	6	.884	**.957**	.769	.857	**1.000**	.828
Outside Influences	6	*.279*	*.217*	.308	.429	*.214*	.310
Behaviors	6	.488	.522	.308	.714	.500	.483
Family Traditions	6	.302	*.217*	.462	*.286*	*.143*	.379
Rivers	7	.860	.870	.846	.857	**1.000**	.793
Beaches	7	.837	.783	**.923**	.857	**.929**	.793
Flora	7	**.930**	**1.000**	.769	**1.000**	**.929**	**.931**
Fauna	7	**.907**	**.913**	.846	**1.000**	.857	**.931**
St. Augustine	7	.605	.652	.385	.857	**.929**	.448
Mayors	7	.674	.652	.769	.571	.571	.724
Revenue	7	.674	.652	.615	.857	.643	.690
Congressional Rep	7	.349	.304	.462	*.286*	*.286*	.379
Migrant Workers	7	.628	.696	.462	.714	.643	.621
Landmarks	7 & 8	.605	.652	.462	.714	.643	.586
Flags	8	.651	.739	.462	.714	.643	.655
International Peace	8	.581	.565	.538	.714	.643	.552
New York City	8	.628	.652	.462	.857	.857	.517
Underdeveloped Country	8	.488	.391	.538	.714	.500	.483
Death Rate	8	**.930**	**.957**	.846	**1.000**	**.929**	**.931**
GDP	8	.465	.391	.308	**1.000**	.714	.345
Total Score	All	63.837	63.913	57.692	75.000	67.857	61.867
Coefficient Alpha		.84	.36[a]	.83[b]	.73[c]	.85	.84

Table 2. P-CCP Human Geography SAFI Omitted Concept Means, Mean Scores, and Cronbach's Alpha by Grade and Gender

Note. Bolded values represent very easy omitted concepts and italicized values represent difficult omitted concepts. a indicates that only omitted concepts specified for the sixth-grade curriculum (4) were used in calculations; b indicates that only omitted concept specified for the seventh-grade curriculum (10) were used in calculations; and c indicates that only omitted concepts specified for the eighth-grade curriculum (7) were used in calculations.

6 Future Research Geography SAFI Map

Analysis of the omitted concepts for grade-specific curricula points to the need for changing the selection of omitted sixth-grade concepts. Of the four concepts selected for omission, two were difficult for the sixth graders; furthermore, the four missing concepts represented some of the most difficult concept at all grades. One course of action is to revise the sixth-grade curriculum as well as the sixth-grade representation on the SAFI. The omitted seventh-grade concepts presented little difficulty for the sixth-graders, thus, the resulting SAFI scores did not differentiate the sixth- and seventh-graders as expected. P-CCP curriculum developers need to determine the extent that the seventh-grade curriculum represents new knowledge, old knowledge presented in a new context, or a review of previously learned material. Additionally, the omitted eighth-grade concepts presented little difficulty for the eighth-graders, and the 7 omitted eighth-grade concepts presented little difficulty for the sixth- or seventh-graders. However, only 7 eighth-grade students participated in the field test; therefore, eighth-grade results should be interpreted with caution.

At this point the research team has not investigated incorrect responses. Anecdotal evidence suggests that the omitted sixth grade concepts were generally used in sixth-grade concept positions, but in incorrect order. In general, the sixth-grade concepts are the most abstract of the SAFI concepts and represented the least generalizable connection to the human geography content structure. These observations need to be addressed in any revision of the curriculum or SAFI for the sixth-grade. Additionally, what developers thought would not be a difficult omitted concept, congressional representative, in fact, turned out to be moderately difficult across all three grades. Most incorrect responses placed this concept in the position intended for mayors—a placement indicating that congressional representatives are part of local governments. The congressional representative for the students' district is a local, very familiar person and could have lead to the students' confusion. This piece of the SAFI needs tweaking to add more clarity.

The research team feels that the SAFI presented in Figure 2 provided a good first step. In the process of revising the SAFI, researchers need to formally clarify the purpose of the developed instrument in evaluating P-CCP students' knowledge. Is the purpose to develop a criterion-referenced measure of students' absolute performance on items considered important to the human geography domain or whether the developers desire variation (beyond grade differentiation) in performance? If the desire is a criterion-referenced measure, the easy omitted concepts need to be evaluated for their importance to the curriculum objectives. Important concepts cannot be removed, but can be revised to add difficulty if appropriate.

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