July 2016

Thank you for your request for **help in identifying some test items that would help assess the pedagogical science content knowledge of certified teachers. Ask A REL** is a collaborative reference desk service provided by the 10 regional educational laboratories (REL) that, by design, functions much in the same way as a technical reference library. It provides references, referrals, and brief responses in the form of citations on research-based education questions. **Please note that REL Southwest has not done an evaluation of the resources themselves, but offers this list to you for your information only. In addition, we provide links to the websites or documents that contain test questions. We do not provide comments on the quality of the questions.**

BACKGROUND

The liaison for Oklahoma Rural Schools Research Alliance received this request from staff at the Oklahoma State Department of Education and submitted it to Ask A REL on their behalf.

Following an established REL Southwest protocol, we conducted a search for research reports, descriptive briefs and assessment programs that provide test items to assess certified science teachers' pedagogical content knowledge (PCK). The sources included federally funded organizations, additional research institutions, educational databases, and general Internet searches using Google and Bing. See the methods section at the end of this Ask a REL response for additional information on how we identified the following sources.

QUESTION

What are some test questions/items that would help assess the pedagogical content knowledge (PCK), in science, of currently certified teachers?

- Certification Examinations for Oklahoma Educators (CEOE),— http://www.ceoe.nesinc.com/PageView.aspx?f=GEN_Tests.html.

In addition to OK educator certification tests, this website provides sample items for various courses and grade levels. Moreover, a hyperlinked list of all the certification areas for science is available. To access the various science tests, one must click on individual "Oklahoma Subject Area Tests" (for example, "Biological Sciences", "Chemistry", "Earth Science" etc.) and then click "view prep materials" and then click "sample selected-response questions" to get to the sample items). The "middle level

science" sample questions, for example, can be accessed at http://www.ceoe.nesinc.com/Content/StudyGuide/OK_SG_SRI_026.htm

- CSET Science Practice Exam http://www.teacherstestprep.com/cset-practice-tests

From the website: "Designed by leading educators based on the exact NES[1]/CTC CSET[2] content specifications, our CSET Practice Tests are as close to the real thing as you can get.

After you've completed your full-length CSET Practice Exam, your test will be instantly auto-graded. You can then view each question you got right and wrong along with the correct answers. You'll also receive a complete diagnostic breakdown of the areas you need to review, an immensely valuable tool as you begin the study process.

Your first CSET Practice Test and basic diagnostics are free."

- Diagnostic Science Assessments for Middle School Teachers http://louisville.edu/education/centers/crmstd/diag-sci-assess-middle.

From the website: "Diagnostic Science Assessments for Middle School Teachers serve two purposes: (1) to describe the breadth and depth of science content knowledge so that researchers and evaluators can determine teacher knowledge growth over time, the effects of particular experiences (courses, professional development) on teachers' knowledge, or relationships among teacher content knowledge, teaching practice, and student performance and (2) to describe middle school teachers' strengths and weaknesses in science knowledge so that teachers can make appropriate decisions with regard to courses or further professional development.

The assessments measure science knowledge in four content domains: (Physical Science; Life Science; Earth/Space Science)[3]. Each assessment is composed of 25 items—20 multiple-choice and 5 open-response. Six versions of each assessment are available in paper-and-pencil format so that researchers, professional development

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[1] *From the CA Credentialing Educator Examinations website:* (http://www.ctcexams.nesinc.com/about_NES.asp.): "The NES® (National Evaluation Series™) is a nationally available teacher certification testing program. The NES teacher certification tests are comprehensive exams aligned to profession-accepted national learning standards, covering areas such as essential academic skills, reading instruction, and commonly taught elementary, middle, and secondary grade-level subjects."

The NES tests are 100% computer-based. A computer-based test design means access to tests by appointment, year round—examinees do not have to wait for an assigned date before testing in a specific field—and immediate score reporting for most results.

[2] *From the CA Credentialing Educator Examinations website:* (http://www.ctcexams.nesinc.com/about_NES.asp.): "The California Subject Examinations for Teachers® (CSET®) have been developed by the California Commission on Teacher Credentialing (CTC) for prospective teachers who choose to or are required to meet specific requirements for certification by taking examinations. The CTC contracted the Evaluation Systems group of Pearson to assist in the development, administration, and scoring of the CSET."

[3] Content subcategories are (1) Atmo/hydrosphere, (2) Lithosphere, and (3) Solar system.

providers, and course instructors can administer them as pre- and post-tests before and after workshops, institutes, or courses to determine growth in teachers' content knowledge. [Free sample tests/questions are available upon request.]

Teams of researchers analyzed a number of standards documents and research literature to synthesize science content middle school teachers should know. Five types of knowledge[4] were also identified. [A hyperlink to the Middle School Science Content Chart is provided] to see a summary of the content analysis of these documents. Science topics that were identified in more than half of the sources were included in the assessments.

Teams of practicing science teachers, science teacher educators, and scientists generated test items intended to simultaneously target a particular content area and a particular knowledge type. Assessment-wide, items were targeted to be balanced across both dimensions.

Evidence of validity of the items for measuring teacher content knowledge in the various categories was established by asking external reviewers to review the items. Items were edited and sorted into randomized sets. They were sent to reviewers along with a review form that solicited: 1) the correct answer to the multiple choice items; 2) categorization of each item into a content category and subcategory; 3) categorization of each item into a knowledge type category; 4) a rating of the item as STS [that is, Science, Technology, and Society Knowledge] or not; and 5) a rating of the appropriateness of the item for middle school teachers.

Reviewers for each content assessment included scientists, science educators, and science teachers. Each item was reviewed by 27-31 reviewers in life science, 29-33 reviewers in physical science, and 20-22 reviewers in earth science. Each person reviewed about 75 items.

Data from the reviewers were analyzed to identify items that met criteria the DTAMS staff established for measuring the assigned constructs. The criteria for an item receiving verification as fitting a content category was that at least 75% of the reviewers identified the item as assessing a given category. To guarantee a balanced distribution within each category, subcategories within the categories had to be agreed upon by more than 50% of the reviewers; both of these criteria were required for an item to be accepted on the content category criterion. The knowledge type criterion was

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[4] **I. *Declarative Knowledge (DEC):*** This is knowledge of definitions and facts. It includes memorized statements of concepts, rules, and laws.
II. Scientific Inquiry *and Procedures (INQ):* This is knowledge of scientific procedures and approaches.
III. Schematic *Knowledge (SCH):* Schematic knowledge represents a deep understanding of science concepts, laws, theories, principles, and rules.
IV. Pedagogical *Content Knowledge (PED):* This knowledge represents strategic knowledge for science teaching — the when, where, and how of it.
Science, Technology, and Society Knowledge (STS): STS addresses the interactions of science with technology and human society. STS knowledge is represented in situations where human needs are a primary purpose for the application of science.

considered acceptable if more than 50% of reviewers rated the item as belonging to one type. For appropriateness, items that received an average ranking over 2.4 (on a scale of 1=low, 2=medium, 3=high) were considered appropriate. If an item met all three of those criteria, it was accepted to be included in the field tests. If it met two of the criteria, it was reviewed to determine if the wording could be clarified or improved. Revised items were or will be sent out for a second review. The items that met review criteria were selected to be the prototype for items in the field tests."

- Misconceptions-Oriented Standards-Based Assessment Resources for Teachers (MOSART) https://www.cfa.harvard.edu/smgphp/mosart/testinventory_2.html.

From the website: "Tests are free to educators; however, since their structure and use differ from many assessment instruments with which you may be familiar, we require anyone seeking access to these instruments to complete tutorials about their design and proper usage. The site will keep track of your progress through the tutorials, and give you direct access to the tests once the tutorials are complete.
The tests[5] available on this website were developed by a team of researchers in the Science Education Department of the Harvard-Smithsonian Center for Astrophysics. The content of the questions is based on published studies of science misconceptions and the NRC National Science Education Standards. Research scientists in the specific content areas evaluated draft questions for scientific accuracy and the development team iterated revisions with the scientists until all comments were resolved. Subsequently, an educator with expertise in literacy reviewed the tests for readability and grade appropriateness. The project team then constructed pilot versions of these tests and administered each test question to 100+ students in the lowest grade level to whom the test would be given. For example, the middle school tests were administered to students in grades 7 and 8. After the pilot data were analyzed, over 1000 students in several grade levels took field test versions of the tests. Thus, the middle school tests were given not only to students in grades 7 and 8, but also to high school students. The result of these efforts for more than 10 years is more than 2,000 multiple-choice test questions addressing most of the NRC's K-12 earth science content standards. The team has developed tests that are available to educators at no cost for downloading from the web as PDF files.

A detailed article on our test development methodologies and some of our findings, focused on development of the K–12 astronomy/space science items, but describing our overall process, can be found in the online journal, *Astronomy Education Review*." The article, described in the section below, can be accessed at https://www.cfa.harvard.edu/smgphp/mosart/images/sadler_article.pdf.

- National Board for Professional Teaching Standards (NBPTS)
https://www.ok.gov/oega/National_Board_Certification/Certification_Areas/index.html

[5] K-4 Astronomy/Space Science; K-4 Earth Science; K-4 Life Science; K-4 Physical Science; 5-8 Astronomy/Space Science; 5-8 Earth Science; 5-8 Life Science; 5-8 Physical Science; 9-12 Astronomy/Space Science; 9-12 Chemistry; 9-12 Earth Science; 9-12 Physics

From the website: "NBPTS offers 25 certificate areas that cover 16 subject areas and are classified into seven student age categories. As a candidate you can opt for a generalist certificate or one that is subject specific.".

Some PDF documents with science sample items (broken out by age range and three different components for each) can be assessed here: http://boardcertifiedteachers.org/certificate-areas

- Ohio Study Guide with Sample Items from the Ohio Assessments for Educators http://www.oh.nesinc.com/PageView.aspx?f=HTML_FRAG/GENRB_PrepStudyGuide.html

From the website: "The Ohio Assessments for Educators will:

- Offer rigorous, state-of-the-art computer-based assessments for Ohio educators to demonstrate required content knowledge and skills.
- Help the Ohio Department of Education and the State Board of Education of Ohio meet their goals of improving student performance and preparing candidates for college and career success by developing, licensing, supporting, and retaining quality educators
- Provide assessments based on contemporary standards of teaching and learning, including Ohio's New Learning Standards

About the Assessments

The assessments included in the program are criterion referenced and standards based… The assessments are aligned with Ohio standards, including Ohio Educational Preparation Standards, Ohio Educator Standards, and Ohio Student Standards. The assessments are computer-based. All assessments include multiple-choice questions, and some assessments also include one or more constructed-response assignments."

- Praxis – ETS (Educational Testing Service) https://www.ets.org/praxis/prepare/materials/5435 (This inks to interactive practice tests, which are available for a fee).

As part of the certification process required by many states and professional licensing organizations, the *Praxis*® tests are taken by individuals entering the teaching profession.

From the website: "**General Science: Content Knowledge, Interactive Practice Test**

Use this interactive practice test to prepare for the General Science: Content Knowledge test (5435). This full-length practice test lets you practice answering one set of authentic test questions in an environment that simulates the computer-delivered test. The practice test is timed just like the real test and allows you to move easily from question to question to simulate what you will experience on the day of the test. After

completing the test, you can also see the correct answers and explanations for each correct answer and view your results by content category.

Note: There is only one version available for each test title, so each time you take the practice test, you answer the same questions in the same order. Retaking or repurchasing the same practice test more than once does not give you different practice questions or change the order in which the questions are delivered."

A free study companion with some sample items is available here: https://www.ets.org/s/praxis/pdf/5435.pdf.

- Texas Examinations of Educator Standards™(TExES™) Program — ETS Practice Test Science 7-12

From the TX Educator Certification website: Interactive Practice Tests are full-length practice tests that include correct answers, explanations for correct answers and an automatic score summary report. The practice *TExES Science 7–12 Test can be found at* https://practice.ets.org/iptmgr/validate.do?s_num=SNPTEXES1070000001

From the TExES Science 7–12 Test Manual: "The TExES Science 7–12 (236) test is designed to assess whether an examinee has the requisite knowledge and skills that an entry-level educator in this field in Texas public schools must possess. The 140 multiple-choice questions are based on the Science 7–12 test framework. Questions on this test range from grades 7–12."

Preparation manuals and full-length practice tests can be accessed at http://cms.texes-ets.org/texes/prepmaterials/texes-preparation-manuals/interactive-practice-test.

ADDITIONAL RESOURCES TO CONSULT

Journal articles

Cobern, W. W., Schuster, D., Adams, B., Skjold, B. A., Muğaloğlu, E. Z., Bentz, and Sparks, Kelly (2014). Pedagogy of science teaching tests: Formative assessments of science teaching orientations, *International Journal of Science Education*, 36:13, 2265-2288, DOI: 10.1080/09500693.2014.918672 http://eric.ed.gov/?id=EJ1033155.

From the ERIC abstract: "A critical aspect of teacher education is gaining pedagogical content knowledge of how to teach science for conceptual understanding. Given the time limitations of college methods courses, it is difficult to touch on more than a fraction of the science topics potentially taught across grades K-8, particularly in the context of relevant pedagogies. This research and development work centers on constructing a formative assessment resource to help expose pre-service teachers to a greater number of science topics within teaching episodes using various modes of instruction. To this end, 100 problem-based, science pedagogy assessment items were developed

via expert group discussions and pilot testing. Each item contains a classroom vignette followed by response choices carefully crafted to include four basic pedagogies (didactic direct, active direct, guided inquiry, and open inquiry). The brief but numerous items allow a substantial increase in the number of science topics that pre-service students may consider. The intention is that students and teachers will be able to share and discuss particular responses to individual items, or else record their responses to collections of items and thereby create a snapshot profile of their teaching orientations. Subsets of items were piloted with students in pre-service science methods courses, and the quantitative results of student responses were spread sufficiently to suggest that the items can be effective for their intended purpose."

Herman, J., Osmundson, E., Dai, Y., Ringstaff, C., and Timms, M. (2015). Investigating the dynamics of formative assessment: Relationships between teacher knowledge, assessment practice and learning, *Assessment in Education: Principles, Policy & Practice*, v22, n3, p344-367. http://eric.ed.gov/?id=EJ1067941.

From the ERIC abstract: "This exploratory study of elementary school science examines questions central to policy, practice and research on formative assessment: What is the quality of teachers' content-pedagogical and assessment knowledge? What is the relationship between teacher knowledge and assessment practice? What is the relationship between teacher knowledge, assessment practice and student learning? Drawing on multiple measures, hierarchical linear modelling and path analysis, results suggest that despite weaknesses in teachers' content-pedagogical and assessment knowledge, teachers' formative assessment practices are positively related to student learning. Relationships between teachers' knowledge and assessment practices are mixed. Findings underscore both the potential and challenge of bringing effective formative practice to fruition as well as the need for continued research."

Jüttner, M., and Neuhaus, B., J. (2013). Validation of a paper-and-pencil test instrument measuring biology teachers' pedagogical content knowledge by using think-aloud, *Journal of Education and Training Studies*, v1, n2, p113-125. http://eric.ed.gov/?id=EJ1054894.

From the ERIC abstract: The topic of "teacher professionalism" is one of the most crucial ones in quality education research. It has a potential to generate results that could inform and hence enhance the practice in classrooms. Thus, research in this field needs reliable instruments to measure the professional knowledge of our teachers to be able to generate reliable results for our research problems. Not many instruments have been developed with regard to this topic. At the same time, an adequate validation of the instrument developed is often missing (Schilling & Hill, 2007). Hence, in a bigger project "ProwiN" (German acronym for professional knowledge of science teachers), test instruments for measuring science teachers' pedagogical, pedagogical content and content knowledge (PK, PCK, and CK) were developed for the subjects biology, chemistry and physics. The present study tested the validity of some of these items which were used to measure the pedagogical content knowledge (PCK) of biology

teachers. These items focused on measuring teachers' professional knowledge by analyzing 1) teachers' "knowledge about student understanding" (or lack of understanding) of several topics in biology and 2) "knowledge about instructional strategies" like the use of models or experiments. The content validity of these instruments was examined by think-aloud interviews with American and German Biology teachers (N = 11). This study shows a high content validity for these items. Furthermore, this paper demonstrates the scope for adapting the conceptual framework of these items to measure biology teachers' PCK in other countries.

McNeill, K. L., González-Howard, M., Katsh-Singer, R. and Loper, S. (2016). Pedagogical content knowledge of argumentation: Using classroom contexts to assess high-quality PCK rather than pseudoargumentation, *Journal of Research in Science Teaching*, v53, n2 p261-290. http://eric.ed.gov/?id=EJ1086856.

From the ERIC abstract: "Despite the recent emphasis on science practices, little work has focused on teachers' knowledge of these key learning goals. The development of high quality assessments for teachers' pedagogical content knowledge (PCK) of science practices, such as argumentation, is important to better assess the needs of teachers and to develop supportive teacher education experiences. In this paper, we present lessons learned from a development process to conceptualize, design, and pilot a measure of teachers' PCK of argumentation. We use the results from our pilot test with 103 middle school science teachers, cognitive interviews with 24 middle school science teachers, and feedback from 10 advisors to present these lessons learned. Specifically, this work resulted in the refinement of our conceptualization of PCK of argumentation in two areas: (1) Moving beyond pseudoargumentation of surface level features to target the quality of structural components and students' dialogic interactions as well as the use of instructional strategies that align with student needs and (2) Focusing on dialogic argumentation in terms of the quality of student interactions in which they build off of and critique each others' claims, rather than goals such as persuasion that are difficult to observe. In addition, the iterative design process suggested that PCK of argumentation assessments should use classroom contexts (such as vignettes, student writing, and video) to activate teachers' knowledge in use by connecting to their prior experiences; however, the student argumentation examples need to highlight one specific strength or challenge and provide sufficient detail around the example to focus the assessment item."

Sadler, P. M., Coyle, H., Miller, J. L., Cook-Smith, N., Dussault, M. and Gould, R. R. (2009). The astronomy and space science concept inventory: Development and validation of assessment instruments aligned with the K–12 national science standards, *Astronomy Education Review (AER),* The American Astronomical Society, v8, n1, DOI: 10.3847/AER2009024.[6] https://www.cfa.harvard.edu/smgphp/mosart/images/sadler_article.pdf

[6] This article is referenced earlier in the test item website source entitled, Misconceptions-Oriented Standards-Based Assessment Resources for Teachers (MOSART).

*From the journal article abstract: "*We report on the development of an item test bank and associated instruments based on those K–12 national standards which involve astronomy and space science. Utilizing hundreds of studies in the science education research literature on student misconceptions, we have constructed 211 unique items that measure the degree to which students abandon such ideas for accepted scientific views. Piloted nationally with 7599 students and their 88 teachers spanning grades 5–12, the items reveal a range of interesting results, particularly student difficulties in mastering the NRC Standards and AAAS Benchmarks. Teachers generally perform well on items covering the standards of the grade level at which they teach, exhibiting few misconceptions of their own. Teachers dramatically overestimate their students' performance, perhaps because they are unaware of their students' misconceptions. Examples are given showing how the developed instruments can be used to assess the effectiveness of instruction and to evaluate the impact of professional development activities for teachers."

Website

- Oklahoma Commission for Teacher Preparation
  https://www.ok.gov/octp/About_OCTP/index.html

From the website: The Oklahoma Commission for Teacher Preparation (OCTP) serves as Oklahoma's independent standards board for teacher education. The enabling legislature of the Commission (HB1549 passed in 1995) charged OCTP with creating a competency-based teacher preparation system that would ensure competent and qualified teachers in every classroom. In order to carry out its legislative charge, the agency assumes three primary responsibilities: the accreditation of teacher preparation programs, the assessment of teacher candidates, and the ongoing growth and development of classroom teachers across the state. Realizing that the greatest determinant of student success is the quality of the classroom teacher, the focus of the Commission is to prepare and support effective teachers from their point of entry into teacher preparation programs and throughout their careers".

This website also has hyperlinks to annual reports that contain statistics for passing rates by test area. Furthermore, some other educational quality initiatives are listed here: https://www.ok.gov/octp/About_OCTP/Initiatives.html

METHODS

Keywords and Search Strings Used in the Searches:

Pedagogical content knowledge, pedagogical content knowledge + science, science teacher assessments, teacher assessment

Search of Databases and Websites

- ERIC database (www.eric.ed.gov)
- Google Scholar (https://scholar.google.com/)

- Google (www.google.com)
- Bing (www.bing.com)

Criteria for Inclusion

REL Southwest selected resources that provide research on test items that would help assess the pedagogical science content knowledge of certified teachers. When REL Southwest staff reviewed resources, we considered – among other things – three factors:

1. Date of Publication: The most current information (primarily published from 2011 to the present) is included.

2. Source and Funder of the Report/Brief/Article: Priority was given to publications written in relevant, peer-reviewed journals or reports or produced by well-known research organizations.

3. Methodology: sources include reported studies, literature reviews and policy reports.

ASK A REL is a service provided by a collaborative of the REL Program, funded by the U.S. Department of Education's Institute of Education Sciences (IES). This response was prepared under contract ED-IES-12-C-0012 with IES, by REL Southwest, administered by SEDL. The content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.