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Developing a Web-Based Mechanism for Assessing Teacher Science Content Knowledge

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Abstract The National Science Teachers Association (NSTA) recently launched a comprehensive electronic professional development (e-PD) online portal, the NSTA Learning Center. This support site for educators currently includes over 6,000 e-PD resources and opportunities available on-demand, as well as various tools designed to help educators maximize the effectiveness of using NSTA resources. One tool, the PD Indexer, helps teachers identify their own areas of content strengths and weaknesses by selecting content-specific assessments. Individual NSTA resources are recommended based on assessment outcomes. This paper presents a detailed description of the procedures employed by NSTA to develop valid and reliable PD Indexer content-specific multiple-choice assessment items.

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Strengthening elementary and middle schoolteacher science content knowledge and science teaching abilities is a national imperative in the United States. Strategic policies outlined within the *America Competes Act* (2007) as well as findings and recommendations from the U.S. Department of Education's *National Commission on Mathematics and Science Teaching for the twenty-first Century* speak directly to the need for improving science content and science pedagogy among elementary and middle school teachers in America (America Competes Act, 2007; American Association for the Advancement of Science 1993; National Research Council 1996; U.S. Department of Education 2000). Given this long-standing imperative and the challenge of supporting the three million teachers in the United States, exploring distributed online models seem axiomatic. Providing a mechanism for teachers to diagnose gaps in content knowledge and select appropriate on-demand, self-directed electronic professional development (PD) tools and resources is one viable solution. In 2001 the National Science Foundation sponsored a survey in which over 5,700 science and mathematics educators across America identified perceived strengths and limitations with science content knowledge. Results of this survey indicated that 71% of elementary teachers in self-contained classrooms (Grades K–4), and 67% of middle level teachers (Grades 5–8) reported a need "…to deepen their own science content knowledge," while only 18–29% of K–4 teachers felt very well prepared to teach physical science, Earth science, and life science (Weiss et al. 2001). An analysis of data from the 2004 National Center for Education Statistics Schools and Staffing Survey indicates that, as of 2007, over 50% of upper elementary teachers in Grades 5–6 are teaching in self-contained classrooms and are responsible for all core subjects, including science, but have little formal preparation in science (Council of Chief State School Officers 2007). These results clearly identify a tremendous need for science content and science pedagogy PD among practicing elementary school educators. From a national perspective, primary challenges facing those invested in improving science education for teachers include the need to design and implement a PD model that is both scalable and sustainable to reach America's 1.7 million elementary teachers of science (U.S. Department of Education and National Center for Education Statistics 2009).

This article does not take a research position, but one of timely and pertinent dissemination of information concerning the development of a personal self-assessment tool in support of self-directed electronic professional development for science educators. The content herein is intended for practitioners, science leaders, and science education administrators interested in learning about what is available from the National Science Teachers Association (NSTA). It discusses the importance of teacher content knowledge as a key component for elementary teacher professional development and describes NSTA's solution to address this need through electronic professional development. Additionally, it documents the rigorous procedures NSTA uses to develop a voluntary personal self-assessment tool to assist educators in diagnosing their individual science education PD resource needs. Detailed procedures for developing and testing this PD self-diagnostic tool are presented, including the results of pilot testing as well as a description of the expert reviews conducted throughout the development process. Also included is a collection of sample items developed for one specific science content area.

Importance of Elementary Teacher Science Content Professional Development

Many researchers now agree that classroom instructional practices are significantly linked to teacher quality as defined by teachers' knowledge and ability to apply subject matter and pedagogical content knowledge related to the subjects taught (Bransford et al. 2000; Council of Chief State School Officers 2007; Darling-Hammond 2006; Goldhaber 2002; Mundry 2005; Wilson et al. 2002). If elementary teachers of science do not possess a comprehensive understanding in these areas and their conception and beliefs concerning the nature of science is poor, research has shown significant and potentially negative impacts to their teaching in the following ways: (a) avoidance of teaching science altogether; (b) limiting time, structure, discourse, and topics selected for learning; (c) utilization of instructional strategies and questions that may limit or fail to formatively assess and build upon students' ideas to facilitate conceptual understanding; (d) failure to inculcate an understanding about the dynamic nature of science; and (e) facilitation of erroneous content knowledge and misconceptions in the students they teach (Abell 2007; Appleton 2007; Griffith 2008; Heywood 2007; Howitt 2007; Kang 2007; Wilson et al. 2002). A lack of science content knowledge, when not part of a coherent conceptual framework, limits a teacher's ability to effectively plan and deliver effective science instruction. This, in turn, facilitates inert knowledge acquisition of science concepts in students as they wrestle with discrete sets of isolated facts and fail to gain an appreciation for the nature of science that facilitates understanding of the concepts in question (Bransford et al. 2000; Fishman et al. 2003; Hanuscin and Lee 2008; Heywood 2007; Luera 2005; Mundry 2005). So the question then is, "What are viable alternatives to costly on-site face-to-face professional development that may extend and enhance delivering PD to scale on a national level alleviating travel cost, release time, and substitute pay typically associated with on-site only models?"

NSTA's Response to Scalable and Sustainable On-Demand Professional Development

One solution that directly addresses the issue of scale is to provide PD online. In April 2008 NSTA formally launched a comprehensive electronic professional development (e-PD) portal called the NSTA Learning Center, which represents a collection of web-based tools designed to help professional educators identify, access, manage, and evaluate professional development resources and opportunities. Anderson's (2003) rationale and guide for the development of effective and efficient distance education provided the theoretical framework used to establish the sufficiency of this self-assessment tool to determine teachers' content learning needs, and therefore to target their online experiences. His equivalency theorem states that a high level of interaction for one of three different interaction forms (learner—instructor; learner—learner, or learner—content) is adequate and does not degrade the educational experience even if the other two interactions are minimal or even absent. As outlined in this article, the rigorous process used to develop both the self-assessment tool and the associated e-PD assures the quality of the student—content interaction provided in the e-learning system NSTA offers.

The Learning Center currently has over 6,000 e-PD resources and opportunities available on-demand to support teachers' individual and unique science education PD needs. Some of the tools available in the Learning Center include an advanced search form enabling teachers to easily locate NSTA resources such as journal articles, archived web-based interactive lectures (web seminar sessions), electronic copies of NSTA Press book chapters, and free self-directed web-based interactive content-specific learning opportunities called Science Objects and SciPacks. Science Objects are 2-h online experiences that employ an inquiry-based design and incorporate interactive and embedded questions to facilitate teacher learning. SciPacks are 10 h long and include three to five science objects, plus a glossary, pedagogical implications component, unlimited email help from content experts (learner-instructor interaction), and an opportunity to complete a final assessment to document content knowledge understanding. When a teacher identifies professional development resources of interest, access to these resources are easily stored and organized into collections within the Learning Center's *My Library* tool. These resources can also be shared with colleagues if desired.

The Learning Center also provides teachers with tools that enable them to identify personal PD goals, manage goal accomplishments, and communicate successful personal goal completions with others through the use of the *My Calendar* and *My Professional Development Plan and Portfolio* tools.

The NSTA PD Indexer Tool

Most of the tools provided in the NSTA Learning Center are designed to help teachers locate, organize, and manage the use of NSTA professional development resources. But the Learning Center also provides a tool designed to help individual teachers identify possible areas of PD related to gaps in specific science content. The *My PD Indexer* tool represents a diagnostic experience in which teachers select general areas of science content and then answer questions related to their chosen topics. These multiple-choice assessment items reflect randomly drawn questions from a database of well-designed questions aligned to specific content areas. Currently, the topics available in the PD Indexer represent many of the specific content areas addressed within Science Objects developed for the general content areas of Earth and space science, life science, and physical science.

The PD Indexer tracks individual results for each diagnostic assessment completed and recommends specific NSTA resources addressing the content of those items not answered correctly. These resources are easily added to a teacher's online library, and specific PD goals are generated based on identified content deficiencies. Recommendations include such resources as journal articles, book chapters, web seminars, online short courses, and Science Objects. When the Learning Center is deployed through a district and state initiative incorporating learner-learner interactions within a larger systematic PD initiative, these items are available for use as pre- and post-assessment instruments to document gain in content knowledge after completing a SciPack. Teachers complete 15–25 items in a content area, such as plate tectonics, and the results are saved for comparison to the post-test (same items) once the SciPack on the same content area is completed. Science Objects and SciPacks represent the most direct remediation to any identified content deficiencies because they were developed to facilitate deeper understanding associated with the content addressed by the PD Indexer items. Additional PD Indexer items are created and made available in the PD Indexer tool as more Science Objects are developed. PD Indexer details may be reviewed at http://learningcenter.nsta.org/indexer/.

Figure 1 presents a screen capture of the PD Indexer tool, including subject knowledge tests available at the time of this writing. If a teacher selects all the items for a discipline (i.e., Earth and space science) five randomly selected questions from each of the available science content topic areas are administered. When teachers score below 80% for individual areas, they are provided selected resources for consideration. Figure 2 presents a sample of recommended resources resulting from the performance of a PD Indexer user. Teachers selecting single content areas, such as rock cycle, complete 10 items from the 15–25 available for each content area, providing more in-depth coverage. The diagnostic PD indexer can be taken as many times as desired by individual users since it is not designed as a summative evaluation tool.

Table 1 shows recent sample usage statistics from the PD Indexer tool. These data indicate that a significant number of users add free resources, such as science objects, to their personal library after viewing the recommendations at the completion of the selected indexer content area. These results indicate that PD Indexer participants use their evaluation information to help them select PD resources targeting specific content needs.

PD Indexer: Pre- and Post-Assessment Item Content Areas

The content areas addressed within the latest round of NSTA PD Indexer item development included the specific topics included in 11 different sets of Science Objects. These Science Objects comprise the content for the following SciPacks: Earth's History; Food Science Safety; Magnetic and Electric Forces; Nature of Light; Resources and Human Impact; Atomic Structure, Chemical Reactions, Elements, Atoms, and Molecules; Nutrition; Cell Division and Differentiation; and Cells and Chemical Reactions. Each SciPack listed contains three or four Science Objects. The outcomes or "evidences of understanding" for all SciPacks are well defined. The components for one of the SciPacks (Earth's History) and a sample of the respective evidences of understanding are presented in Fig. 3.

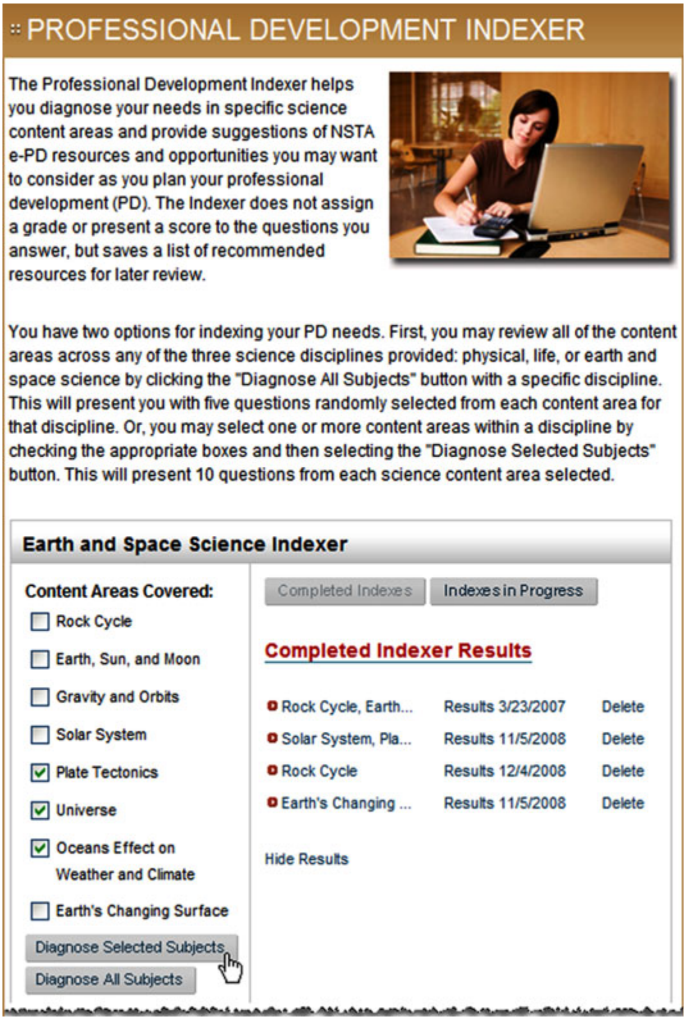


Fig. 1 PD indexer tool depicting prior saved results and new content areas for assessment

The overall goal of this round of PD Indexer item development was to generate enough items to ensure that at least five well-designed, effective items for each Science Object could be selected, resulting in final test sets for each SciPack that include 15 and 25 items. The rigorous, 4-stage process for indexer item development ensures valid and reliable items and involves the stages summarized below.

Stage 1: Develop Draft Items

Item developers were selected by members of the NSTA PD Indexer development team based on their previous work with NSTA, their demonstrated grasp of the

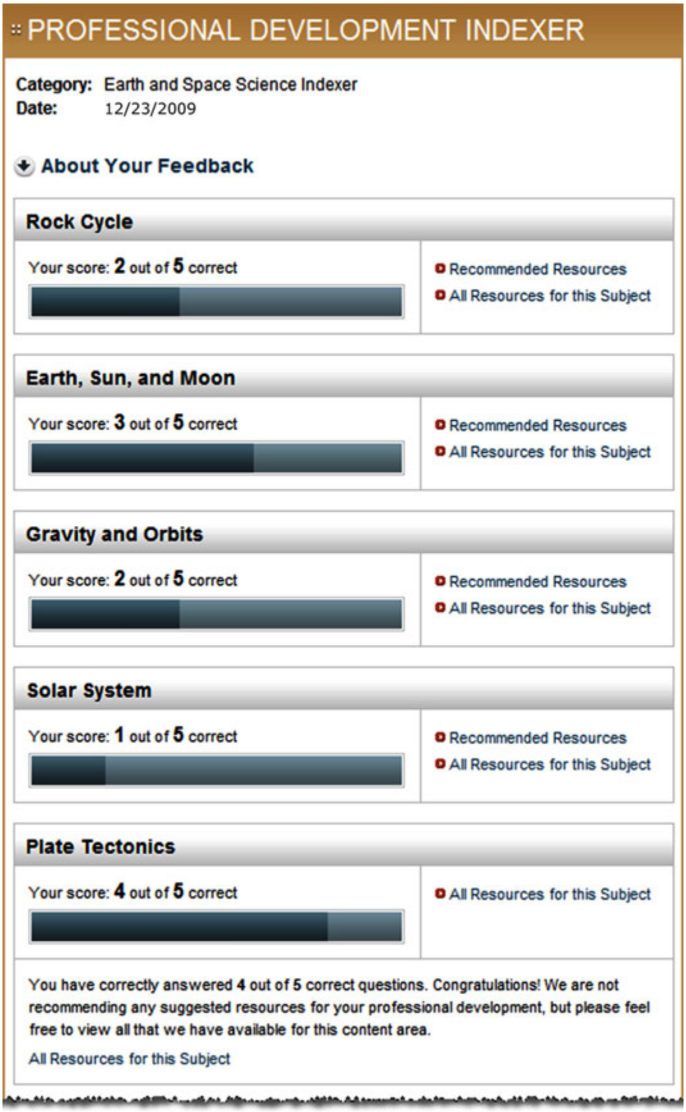
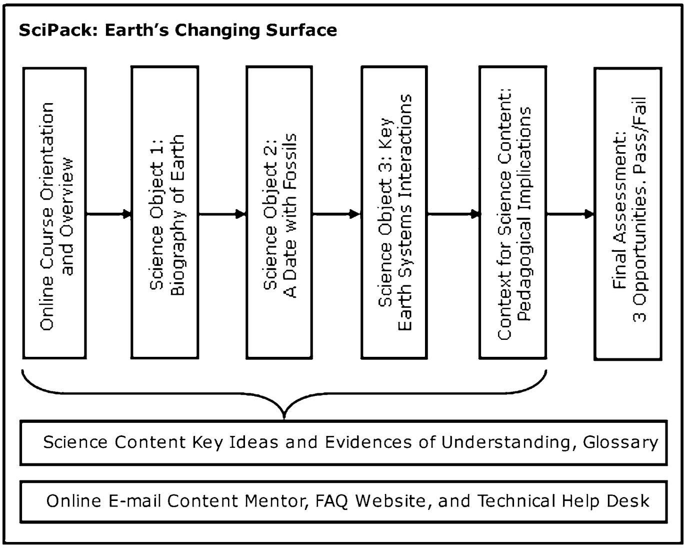


Fig. 2 Results after completing PD indexer for all topics available in earth and space science

content knowledge, and in some cases their previously identified status as master teachers. For example, a recently retired master biology teacher with experience in item development for WestEd was secured for the topic of Food Science Safety. A retired master teacher in physics, who had experience in national curriculum development, generated draft items for Atomic Structure and Magnetic and Electric Forces content areas. Several retired district and state science administrators with earned doctoral degrees and national board certification assisted in generating draft items for the science topics in biology and resources and human impact.

Table 1 Sample PD indexer usage and actions from recommendation results as of 9/11/2009

PD indexer content area	Number of individuals that voluntarily completed the indexer	Number of individuals that added Science Objects to their library	Number of individuals that added SciPacks to their library
Ocean's effect on weather and climate	614	231	329
Cell structure and function	509	343	190
Energy	861	505	347



Science Object 1 Evidences of Understanding: Biography of Earth

EH1.1 Describe the key events in the early history of Earth's formation and the relative times of their occurrence in Earth's history.
EH1.2 Explain scientists' estimation of the age of rocks at Earth's surface by referring to evidence.
EH1.3 Explain scientists' estimation of the age of Earth by referring to evidence.
EH1.4 Describe the limitations of radioactive dating methods.
EH1.4 Compare the physical principles and particular processes at work in Earth's history and today that are significant to determine the age of Earth.
EH1.6 Differentiate between the observations (evidence) and inferences that scientists use in establishing the age of Earth.

Fig. 3 SciPack components and evidences of understanding for science object 1

All item developers participated in a training session facilitated by an assessment expert before the initial sets of items were developed. This session was designed to help the developers create valid multiple choice assessment items within the parameters of the web-based pilot-testing environment. Strategies to create and reference graphics within the items were discussed, and the mechanisms to submit items and revise them using web-based tools were demonstrated. Additionally, the item developers were provided with documents that detailed the evidences of understanding as well as background information associated with the content addressed within their assigned SciPack topic. Access to the material developed for the actual SciPack was provided as well.

The item developers created items for each Science Object based on their respective evidences of understanding and submitted them to the PD Indexer team upon completion. Once an initial set of items was developed, it was submitted to a subject matter expert for content review. The reviewers were experts in their respective fields with doctoral degrees in the appropriate science content area under review. For example, a professor with a PhD in biology reviewed assessment items for the cell division and differentiation topic, and a university professor with a PhD in physics reviewed items for the nature of light topic.

Based on the feedback of subject matter experts, individual items were edited by either the item developer or members of the PD Indexer team. In some cases, items were discarded if they were too similar to existing, usable items or, in rare cases, if they were too difficult to repair without completely rewriting the entire item. At this stage, the project assessment expert also reviewed items to ensure they conformed to guidelines reflecting valid and reliable multiple-choice assessment item development. These criteria were based on a number of assessment design models (Bashaw 1991; Dick et al. 2008; Gagne and Driscoll 1988; Merrill and Tennyson 1994; Popham 2008; Sullivan and Higgins 1983) and included such strategies for well-developed multiple-choice assessment as (a) items are free of prompts or cues that could be used to determine the correct answer; (b) no choices (distracters) are obviously incorrect; (c) words such as *a, an, he, she,* or plural words are not used to cue learners toward the correct answer; (d) words such as "All" or "Never" are not used in the answer options; and (e) key concept words from the question are not repeated in the answer options.

Stage 2: Pilot Tests

Once the overall set of assessment items for each topic was developed and edited (approximately 3 times the target number of assessment items), the items were entered into NSTA's online assessment system for pilot testing. Pilot testers were recruited from NSTA membership. In order to reach the SciPack target audience of middle school teachers, e-mail contacts were selected from NSTA's database of members who subscribe to the NSTA middle school journal *Science Scope.* The testing was scheduled to be open for 1 week or until the target of 100 pilot testers for each topic was reached. After 100 pilot testers completed a test, it was closed for further participation. If the target number of pilot tests were not completed within 3 days, a follow-up e-mail was sent. In most cases, the target number of testers was reached within 3 days of the initial e-mail.

When the pilot testing was completed, the data were exported, formatted, and sent to a psychometrician for independent item analysis. The statistics generated in the item analysis for one actual pilot test item are presented in Table 2. The objective of the initial item analysis was to identify obvious candidates for the final

Table 2 Sample statistical analysis results for single pilot test item

Item 3: * is keyed	1*	2	3	4
Responses	82.0%	4.5%	8.1%	5.4%
Upper 33%	91.9%	.0%	2.7%	5.4%
Lower 33%	73.5%	8.8%	8.8%	8.8%
Item-total				
Point Biserial	.259	−.243	−.077	−.125
Item-remainder				
Point Biserial	.207	−.221	−.042	−.098

version of each test based on reliability measures, identify items that might require some modification, and eliminate items that did not measure their targeted outcomes within acceptable parameters of statistical reliability.

For each item, a response distracter analysis was first provided. This analysis reported the percentage of respondents selecting each choice. Each analysis further reported percentages by the top and bottom one-third performing group based on overall test score. The correct response for each item was identified with an asterisk (*) and the additional distracters were identified. This analysis documented the degree to which test-takers were drawn to each of the distracters (i.e., incorrect choices). Low percentages of respondents selecting certain distracters might indicate a weak distracter. If a large percentage of respondents from the upper third performing group (i.e., "high ability" participants) selected the same incorrect distracter, the statement was carefully examined to determine whether it could be correct, or whether the wording of the distracter made it too plausible. The percentage of responses for the keyed-correct choice reflected the item's difficulty level. The analysis illustrated in Table 2 indicates a correct response rate of 82%, which, based upon the skill measured by the item, resulted in its exclusion from the final assessment set.

The next set of statistics presented in Table 2 illustrates the item's discriminating power (i.e., the ability of the item to accurately differentiate more knowledgeable respondents from less knowledgeable respondents). Point biserial correlations were calculated for each item, representing the average relationship between the participants' performances on a single item (correct or incorrect) versus how well they performed on the entire test. Like most correlations, this calculation is reported as a coefficient between -1 (a perfect negative relationship) and +1 (a perfect positive relationship). A positive coefficient implies that respondents who selected a specific distracter scored higher on the overall test, while a negative coefficient implies the opposite. Note that the point biserial statistics are provided for the "Item-Total" and "Item-Remainder." In the current setting, the latter presents a more accurate picture as it evaluates the relationship of the item with a total score *removing the effect of the item under examination.*

For diagnostic purposes, these statistics were provided for each choice. In examining the efficacy of each item, the PD Indexer development team selected positive point-biserial correlations greater than +.20 (Nunnally 1967) as the absolute minimum for inclusion in the final set. In some cases, point biserial scores were so aberrant (i.e., −.90) that the item was evaluated to ensure the scoring key was correct, or that more than one correct answer was not provided. According to Crocker and Algina (1986), common causes for aberrant response patterns include: no correct answers to an item, multiple correct answers to an item, an item written in such a way that "high ability" persons read more into the item than intended and thus choose an unintended distracter while "low ability" people are not distracted by a subtlety in the item and answer it as intended, an item having nothing to do with the topic being tested, or a mistakenly keyed incorrect response as the correct one on the scoring key. Items following an aberrant point-biserial pattern were subject to modification or elimination.

An example summary of the item difficulty levels and item-remainder point-biserials for the science content topic of Earth's History items are included in Table 2.

Stage 3: Select Final Items

After all the analyses were conducted for the pilot test items, the results were submitted to item review team members. These item reviewers were selected for their experience in the appropriate subject matter areas and assessment item development. This panel included expertise in both content and assessment. For example, a university faculty in the subject area in question (e.g., PhD professor of Earth science at the University of Northern Iowa) reviewed with a senior researcher from major education institutions and organizations (e.g., Westat and Department of Education State Science Assessment Directors). Reviewers used the item-level analysis to determine item quality, and they evaluated each item whose point biserial scores may have been aberrant. Reviewers also analyzed each item for bias based on the *ETS Fairness Review Guidelines* (Educational Testing Service 2009). Bias was evaluated according to the categories detailed by Hambleton and Rodgers (2004): content, language, structure, formatting fairness, and stereotyping.

Once an item was identified as reliable and unbiased, review team members evaluated the degree to which it appeared to align with the stated evidence of understanding. Although the item developers in consultation with an assessment expert previously addressed such alignment issues, review team members ranked the degree to which multiple items addressed specific evidences of understanding, based on their own understanding of the evidences. After establishing the intent of each evidence of understanding, reviewers used the following criteria to rate the alignment of each candidate item:

Level	Criteria	Recommended action
3	Item completely meets the intent	Keep
2	Item meets most of the intent	Revise part needed to match
1	Item partially meets the intent	Completely revise or eliminate
0	Item does not meet the intent	Eliminate

Reviewers worked individually reviewing items for degree of match, recording responses on an Item Content Alignment Form. For example, the reviewers for assessment items developed for the Magnetic and Electric Forces suggested improvements such as more accurate representations for illustrations, replacing distracters if a significant percentage of low-scoring respondents selected a distracter, or increasing the length for certain distracters to equalize length. Each independent reviewer completed a summary sheet that included item quality, bias, and alignment scores.

All summary sheets presenting the alignment scores, bias feedback, point biserial data, recommendations, and general comments from each of the items were aggregated for analysis. Members of the PD Indexer team then assessed these reviews, and decisions were made regarding the selection of items to be included in the PD Indexer. In most cases, if both reviewers recommended items, they were included in the final set. If there was a discrepancy (i.e., recommended by one reviewer but not by the other), notes on the items were evaluated to determine if a simple edit might address concerns.

Once the final sets of items for all 11 SciPacks were identified, test-level statistical analyses were conducted on the pilot test results for the selected items. The data in Table 3 present the number of items selected for each set, the number of pilot test results for each test, mean and standard deviation, median and quartile scores, and Cronbach Alpha internal consistency correlation statistics.

Based on the data presented in Table 3, the PD Indexer development team approved the final set of items. There was some concern that the Resources and Human Impact test results indicated an assessment that was not adequately

Table 3 Test-level statistical analysis results

Test	No. of items	No. of cases	Mean	Std deviation	1st Qrtile	Median	3rd Qrtile	Internal consistency[a]
Earth history	20	111	62.3	18.2	50	60	75	.704
Food science safety	22	102	61.7	19.1	45	62	77	.787
Magnetic and electric forces	22	114	56.1	21.9	36	55	73	.821
Nature of light	20	105	55.6	19.7	40	55	70	.737
Resources and human impact	16	100	79.0	15.2	69	81	91	.656
Atomic structure	16	102	65.9	27.0	50	75	88	.882
Chemical reactions	23	101	60.5	24.6	39	61	83	.877
Elements, atoms, and molecules	28	103	83.3	14.3	75	86	93	.812
Nutrition	20	97	67.5	14.9	60	70	75	.609
Cell division and differentiation	22	97	69.1	17.4	59	73	82	.752
Cells and chemical reactions	24	94	59.4	20.1	46	58	75	.821

[a] Chronbach's Alpha

discriminating, with a mean score of 79% and a lower reliability score (.656). However, the evidences of understanding measured by the selected items generally addressed lower cognitive ability, and the items did align well with these evidences. The same argument is posited for Nutrition.

Stage 4: Final Item Preparation

Before the items were placed into the online PD Indexer system, the text of the items was sent to an editor, and the graphics for those items requiring them were sent to a graphic designer to ensure that they were clear and easily decipherable. The Senior Director of e-Learning Production then reviewed the items and, in coordination with the technology staff, placed items in the online tool available for use. When used within the PD indexer to diagnose teachers' content knowledge, correct answers and scores are not reported for the end user, and only a smaller subset of the 20- to 15-item bank is available. When the items are used as a pre/post assessment instrument, the entire bank of items in a content area is presented for the learner. Table 4 provides a sample of two items for Magnetic and Electric Forces, which collectively reported a Chronbach Alpha internal consistency reliability of .821 in Table 3.

Summary

Helping our nation's 1.7 million elementary science teachers better understand the science content they teach was the primary reason the NSTA launched an on-demand electronic professional development portal called the Learning Center in April 2008. This e-PD tool currently provides over 6,000 distinct resources and opportunities, with over 1,850 completely free. A suite of freely available tools also resides within the portal to help educators plan, track, and document their growth over time. The PD Indexer represents just one of these tools, but it remains an important asset supporting all other tools and resources because it assists teachers in diagnosing their individual PD science content needs. The rigorous development process of the PD Indexer, coupled with quality resources recommended based on the assessment, help assure a high level of learner—content interactions necessary for effective and efficient distance education (Anderson 2003). NSTA has expended significant effort to ensure that the items in the PD Indexer self-assessment tool are internally valid and reliable, and that the recommended resources, such as the free Science Objects, are high quality and effective, thus providing teachers an on-demand, self-directed e-PD resource to meet their individual needs at a time, place, and convenient pace. Figure 4 reflects the positive usage trends of the NSTA Learning Center and its e-PD resources over the past year. These encouraging data indicate that over 62,000 teacher accounts currently include over 430,000 individual e-PD resources in their online libraries. If this trend continues, the Learning Center may significantly help address the challenge of increasing K–8 teachers' competence in science education via a model that is sustainable on a national level to address the scale needed for our country's teachers of science.

Table 4 Final PD indexer—pre/post assessment item set for magnetic and electric forces

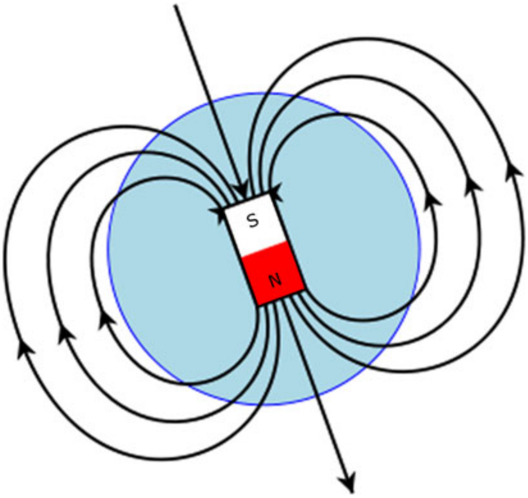
Item 1 ID	MEF1.1.2
Question	Docents at science museums often invite a student with long hair to step up to the podium and participate in a demonstration on static electricity. With all safety measures in place, the student is asked to place two hands on the ball of a Van de Graff generator  The student's individual hair strands collect the same charge, and the hair sprays out from the head as depicted in the photograph. Which of the following statements best explains what causes this person's hair to stand on end?
Correct Answer	The individual hair strands are all the same charge, so they repel each other
Distracter 1	The hair strands stand up so that they can transmit the electrons from the generator to the air
Distracter 2	Hair strands are forced up because of the repulsion of the opposite charge collecting at the feet of the student
Distracter 3	Hair strands repel each other because of the energy of the neutrons flowing through the Van de Graff generator to the student
Item 20 ID MEF3.2.5	
Question	The Earth's magnetic field is represented in the field line diagram  Which of the following statements best explains the existence of the Earth's magnetic field?

Table 4 continued

Item 20 ID	MEF3.2.5
Correct Answer	The Earth's magnetic field exists because currents move in the outer core producing electric currents
Distracter 1	The Earth's magnetic field exists because lodestone and metallic minerals are found in the crust
Distracter 2	The Earth's magnetic field exists because the Earth's core largely consists of mono-polar materials
Distracter 3	The Earth's magnetic field exists because solar winds from the Sun strip electrons off of the crust near the northern pole, making the Earth into a huge bar magnet

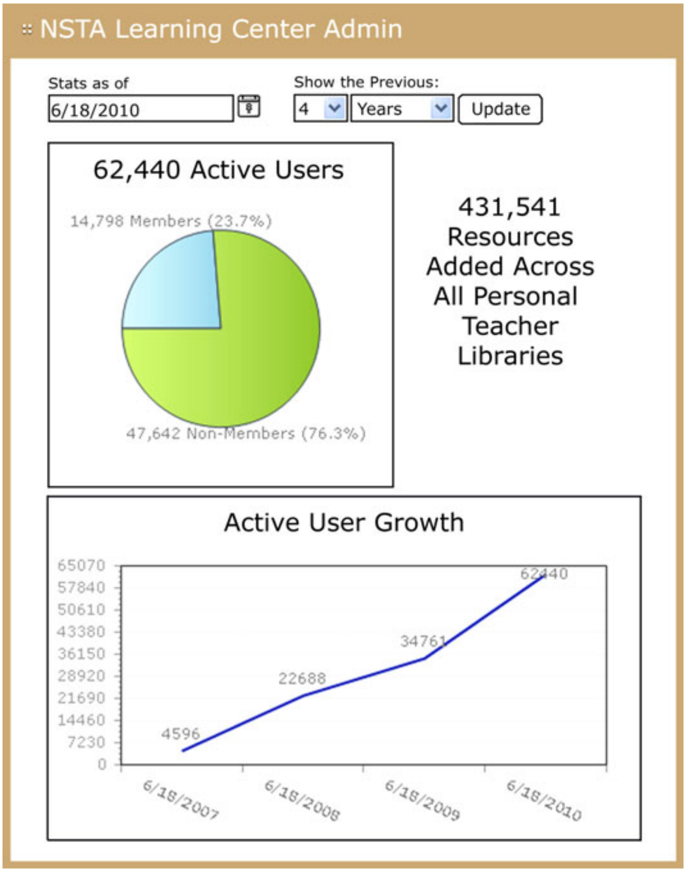


Fig. 4 Learning center account trajectory and resource usage as of September

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