Blended Professional Learning for Science Educators:

The NSTA Learning Center

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Abstract

Blended learning solutions for teachers that effectively integrate online learning with locally deployed onsite efforts provide access to convenient, immediate, and self-directed learning resources, tools, and discourse opportunities that would otherwise not be available. When blended learning systems are closely tied to the local curriculum or instructor course outcomes, as well as made part of an on-going, coherent, and integrated learning design, blended learning extends and enhances local face-to-face professional learning efforts and achieves scale at a cost that is affordable and sustainable. The National Science Teachers Association (NSTA) maintains an online Learning Center that now has over 165,000 teachers spending many hours online completing self-directed on-demand web modules, taking formal online courses with our partners, participating in web seminars and virtual conferences, and sharing online digital resource collections through moderated discussion forums. The NSTA Learning Center currently has over 90,000 personally uploaded resources, nearly 8,000 teacher-generated public collections, and over 33,000 user generated posts on 3,000 topics across 14 forums. We have formally collaborated with dozens of school districts, along with over 70 universities that use the Learning Center as part of their blended learning solution. We will share challenges, successes, and insights into how our platform may be configured for the local needs of individuals as well as institutions of higher education. We will provide three brief university case examples.

Strategy for Educational Improvement

Strengthening teachers' science content knowledge and teaching abilities has been a national priority for decades. Many researchers agree that teachers' effectiveness in the classroom is linked significantly to their knowledge of subject matter and pedagogical content knowledge. A weak command of subject matter causes teachers to: (a) avoid teaching certain science topics; (b) select inappropriate instructional strategies that reduce student understanding or conceptualization; (c) pass on erroneous content knowledge and misconceptions to students; and/or (d) a focus on isolated facts versus facilitating a deeper conceptual understanding of the concept or phenomena (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000; A. S. Byers, Koba, Sherman, Scheppke, & Bolus, 2011; Council of Chief State School Officers, 2007; Darling-Hammond, 2006; Goldhaber, 2002; Mundry, 2005; Wilson, Floden, & Ferrini-Mundy, 2002). For the two million science teachers in the United States, it is challenging to increase teacher subject-matter knowledge and pedagogical knowledge at a sustainable scale. One axiomatic way to address this challenge is by using online systems to extend and enhance face-to-face professional learning within a school district. Indeed, the U.S. Department of Education National Technology Education Plan recommends online learning for teachers as it affords them immediate access to resources, experts, and colleagues that would otherwise not be available (US Department of Education, 2010b).

Research also demonstrates that multi-dimensional learning experiences delivered in an integrated fashion improve teacher engagement and learning (Honey, Pearson, Schweingruber, Education, 2014) and show stronger learning outcomes than face-to-face alone (US Department of Education, 2010a). Professional learning is most powerful when it is embedded and sustained through the work of communities of practice. Teacher participation in online communities of

practice (OCoPs) can foster communication, collaboration, and support among teachers and reduce feelings of disconnectedness or isolation (Office of Education Technology, 2010). Educators working and learning together in teams—in efforts aligned with and in support of their local curriculum efforts—can build a culture of success that improves school performance and student achievement.

One way that online resources could enhance teacher professional learning (PL) is by creating an infrastructure for blended professional learning programs. Blended PL combines onsite, face-to-face experiences with online opportunities that extend and enhance the face-to-face offerings. Recent research has extolled the virtue of such programs over a “one-shot”, or “one-size fits all” approach. Blended PL should integrate the best of onsite learning with online opportunities that provide immediacy, convenience, self-direction, and collaboration with other colleagues and experts via professional learning communities (US Department of Education, 2010a).

Many institutions, with the best of intentions in mind, provide blended PL experiences by purchasing bulk subscriptions that grant access to a digital repository of lesson plans, teacher practice videos, and/or online short courses. Unfortunately, without integrating the onsite and online components, these blended PL options are more akin to a bolt-on approach. This could create a Frankenstein effect that fails to inculcate a coherent, integrated, and year-long learning experience. Further, to be effective, learning communities must have skilled facilitators, a variety of collaborative online tools, and stable, user-friendly platforms (Fulton & Britton, 2011). Because of such issues, in order for teachers, administrators and university instructors to effectively facilitate blended PL in their environments, they must also experience blended PL firsthand as part of their own professional growth.

Ever since 2010, the National Science Teachers Association (NSTA) has strived to create a blended-learning professional learning platform named the NSTA Learning Center (NSTA LC). The NLC was designed to provide blended PL that is driven both by emerging technology and the end-user needs of teachers, schools, districts and university. The goal of the NSTA Learning Center is to enhance the personal learning of educators by providing a suite of tools, resources, and opportunities that support their long term growth based on their unique learning needs and preferences within a collaborative learning community.

The initial NLC took the form of a directory of formal, online science courses. We then envisioned a need for just-in-time learning that might be offered at a smaller grain size and not require educators to wait until the next formal course was offered. This would seem especially useful when teachers only needed a refresher in a particular subject-matter area or pedagogical strategy. As a result, we developed a series of interactive, self-directed teacher web modules called SciPacks. These SciPacks are bundles of separate Science Objects. For example, the SciPack called Force and Motion contains Science Objects entitled: Position and Motion, Newton's 1st Law, Newton's 2nd Law, Newton's 3rd Law, and a Pedagogical Content Knowledge object (Center, 2008). The SciPacks were created using development principles from Wiggins and McTighe's *Understanding by Design*, as well as Dick and Carey's *Instructional Systems Design Models*. Design templates based on a "Five E" inquiry model were developed to help ensure consistency across the modules and deeper teacher engagement beyond simply a "click-next" approach. We also incorporate varied interactive media and high touch experiences for the teacher such as embedded simulations, multiple choice questions, animations, slide shows, hands-on activities, and drag-n-drop interactives (Figure 1).

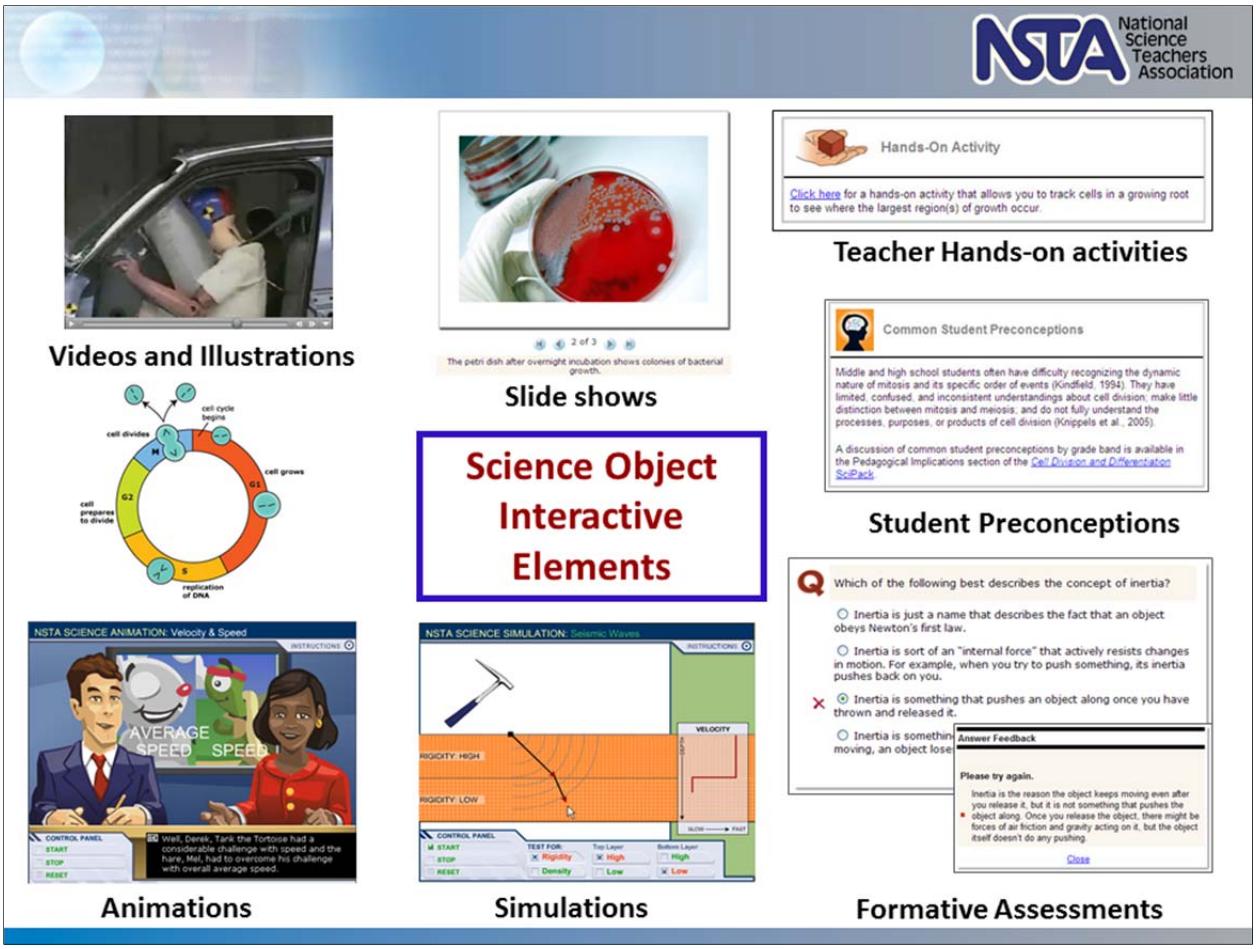


Figure 1. Scipacks embed multiple interactive experiences to facilitate self-directed learning.

Initial SciPack development involved collaboration between three higher education institutions as well as initial funding from both the U.S. Department of Education and the Hewlett Foundation. As time progressed, with funding from the National Science Foundation, we applied the principle of convergence by creating a single online destination where educators might access and consume all NSTA digital content and learning opportunities.

Similarly, with the adoption of the K12 Framework for Science Education and the NGSS, there is a real need to identify resource exemplars where educators can see, discuss, and share effective lessons and units that weave together the scientific and engineering practices,

disciplinary core ideas, and cross-cutting concepts of the NGSS. An online platform that facilitates the creation, sharing, and rating of instructional units against a common set of metrics is currently in high demand. NSTA is working toward these ends with the integration of our NGSS@NSTA Hub (NSTA, 2014), where a cadre of trained curators are evaluating instructional materials that support the NGSS (NSTA & Achieve, 2014). The NSTA.org hub will integrate the NSTA LC moderated discussion forums and personal library tools allowing users to create, share, and rate our entire collection of digital resources, as well as those from across the open network.

Audience

The NLC currently has over 165,000 teachers who spend hours online each week completing self-directed on-demand web modules and formal online courses with our partners, participate in web seminars and virtual conferences, and share online digital resource collections through our moderated discussion forums. We currently have over 90,000 personally uploaded resources; over 8,000 teacher-generated public collections and over 33,000 user generated posts on 3,000 topics across 14 forums (Figure 2). You do not need to be a member of NSTA to access over 4,200 free digital resources, our personal diagnostic tools, or the integrated community forums.

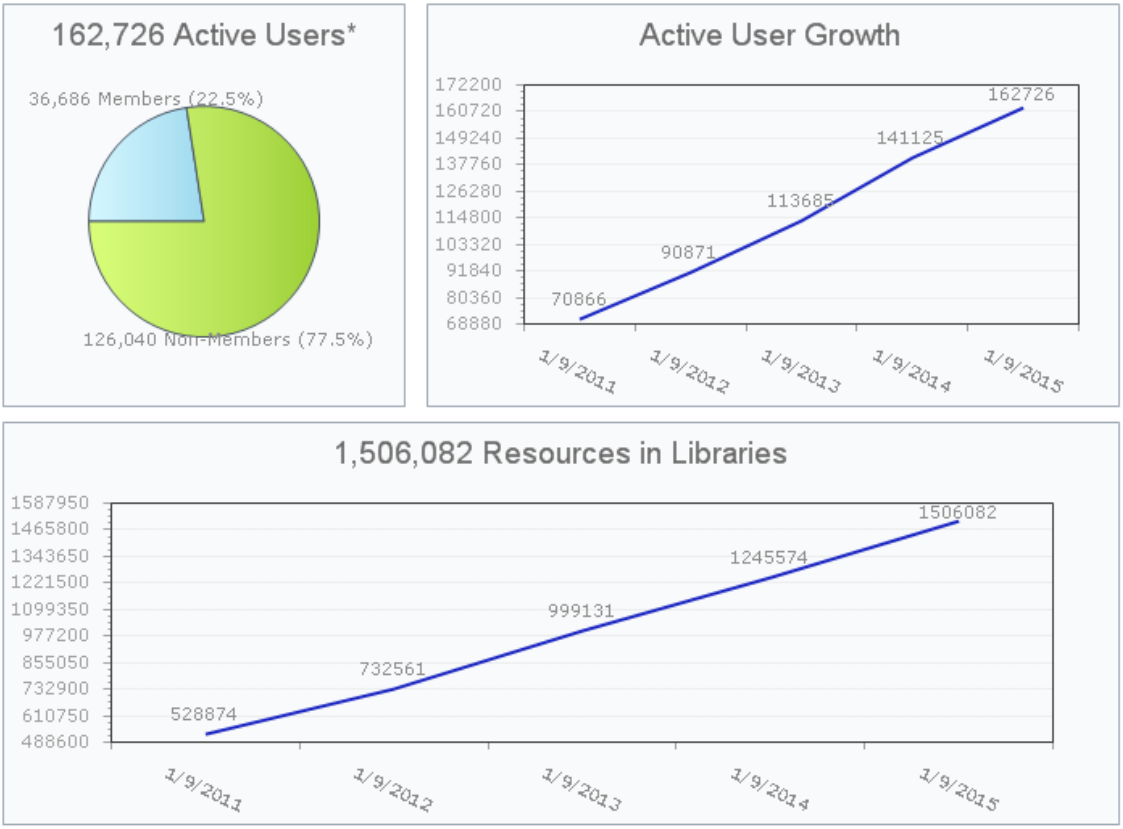


Figure 2. The NSTA Learning Center's breakdown of users, trend lines in growth over the last five years.

The audiences that leverage the NLC's digital resources vary based on the goal of the recipient(s). There are two primary user groups. The first group consists of individual K–12 educators who are further subdivided into NSTA members or non-members. The second group consists of in-service teachers that are part of a school district cohort group or pre-service or graduate school educators that are part of a university cohort. The district cohorts are managed by the science district administrators and the university cohorts are managed by science methods professors.

Individual teachers using the NSTA Learning Center receive a needs-based, on-demand, and self-directed learning experience. Teachers can select digital resources and learning opportunities from a plethora of alternatives including NSTA Press e-Book chapters, NSTA

Press e-journal articles, interactive web modules, synchronous or archived web seminars, virtual conferences, podcasts, and formal, third-party online courses (Center, 2009, 2014c). These individual resources are also assembled into thematic and grade-banded collections.

A suite of free tools scaffolds the self-directed learner's long-term growth. A PD Indexer tool helps teachers diagnose or "index" their PL needs by formatively assessing their understanding of disciplinary core ideas in science. The formative assessment takes the form of a bank of multiple choice questions (Figure 3). These assessments undergo a rigorous development process to ensure validity and reliability (A. S. Byers et al., 2011). The Indexer then recommends free and fee-based digital resources and online learning experiences that teachers may then add to their library or long-term growths plans using the free Professional Development Plan and Portfolio tool. Future re-designs of the NSTA Learning Center (completed summer 2015), will have Teacher Learning Journey's that couple coherent resources and experiences together into a package other may also traverse, rate and share as desired. A YouTube video describes this vision (https://www.youtube.com/watch?v=AlLXfE4YVec), and a pilot study conducted in cooperation with NSTA, NASA and Penn State found teachers were highly engaged when allowed to create learning plans based on their own needs and preferences coupled with badges to validate their completion (Gamrat, Zimmerman, Dudek, & Peck, 2014).

PROFESSIONAL DEVELOPMENT INDEXER

Current Subject: Oceans Effect on Weather and Climate Your Progress: 3 of 10

The average difference in daily temperature change from the day's low to the day's high for a typical day in New York City is roughly 10 degree Fahrenheit, whereas the average temperature change in Topeka Kansas is more than 20 degrees Fahrenheit. Which of the following most likely explains this difference in average daily temperature fluctuations?

- ◯ Topeka is closer to the equator than New York City.
- ◯ There is less pollution in Topeka, which allows the air temperatures to be less influenced by warming greenhouse gasses.
- ◯ Kansas is blanketed in cool air from Canada at night, and warm air from the Gulf of Mexico during the day.
- ◯ New York City is a coastal town whose temperature fluctuations are moderated by the nearby Atlantic Ocean.

Submit Answer

PROFESSIONAL DEVELOPMENT INDEXER

Category: Earth and Space Science Indexer
Date: 10/24/2014

About Your Feedback

Collapse All Recommended Resources

Oceans Effect on Weather and Climate

Your score: **4** out of **10** correct

Close Resources
All Resources for this Subject

Oceans Effect on Weather and Climate

Click on the resource's title to add it to your library or cart.

Changing Climate

Ocean's Effect on Weather and Climate: Changing Climate

Science Object

Add to PD Plan

Science Objects are two hour on-line interactive inquiry-based content modules that help teachers better understand the science content they teach. This Science Object, co-developed between NOAA and NSTA, is the fourth of four Science Objects in the Ocean's

Member Price: Free **Nonmember Price: Free**

Grade Level: Elementary School, Middle School

Figure 3. a) Sample assessment item within the PD Indexer, and b) Sample assessment report from PD Indexer.

Cohort groups may deploy a fully-blended approach. Both online and onsite experiences should be seamlessly integrated for the most coherent experience with strategies that help learners recognize and leverage onsite experiences when online and vice versa (Berger, Eylon, & Bagno, 2008). Many IHE"s facilitate blended year-long teacher PL programs through district collaborations, as part of a University Mathematics and Science Partnership program sponsored through the U.S. Department of Education (Program, 2014), or as part of an onsite university science methods course.

Each institution using the NSTA LC configures their platform depending on their needs and goals. For example, many universities use the PD Indexer tool as a pre- and post-assessment to then guide pre-service teacher SciPack selection and lesson unit planning and implementation. The initial data collected by the indexer provides a baseline of teacher understanding within a particular science content area. The PD Indexer data can then be reviewed after blended, PL experiences to help determine learning and growth. Our SciPacks award a certificate and virtual badge if teachers complete all of the embedded and end-of-chapter quizzes in a module, as well as pass a final assessment. Districts often times offer additional rewards and incentives as teachers pass SciPacks, such as teacher stipends, release time, and/or continuing education credits. Universities many times integrate SciPacks as part of the requisites for overall course completion and graduate credit.

Research and third-party evaluations have documented significant gains in teacher learning and self-efficacy across multiple grade levels and science content areas when SciPacks

are used in conjunction with onsite efforts (Center, 2014b; O'Connor, Chadwick, & Samanta, 2010; Sherman, Byers, & Rapp, 2008). There are now over 74,000 educators who have added over 720,000 SciPacks, and their related Science Objects across their personal libraries. In our own studies, we also frequently document significant gains in teacher understanding of key ideas in science after completing a SciPack. This does not imply that the teacher is now certified to teach this subject, but instead, it documents knowledge acquisition beyond the typical "seat time" and teacher perception surveys that are often the sole determinants of PD effectiveness (Guskey, 2003).

The NSTA supports pre-service teachers leveraging the NSTA LC and its tools and digital resources as an "e-textbook." In the fall semester of 2014, over 50 universities registered to use the NLC to educate their pre-service teachers via blended learning solutions (Center, 2014a). A list of IHE's that incorporate the NSTA LC as part of their strategic efforts is available for review: http://learningcenter.nsta.org/group/etextbook.aspx. In these instances, science method professors select e-book chapters, e-journal articles, SciPacks, and archived web seminars to create their own e-textbook. The professors then further customize their e-textbook by appending their own digital resources as part of the collections. All pre-service e-textbook subscriptions include a full NSTA student membership for each pre-service student. This also provides each student with his or her own annual print copy of a NSTA print journal of their choice (one a month for nine months).

During professors' courses, they typically let students self-assess their understanding of particular science concepts via the PD Indexer tool, assign readings from their NLC collection, and let students complete selected SciPacks. Many times the professors incorporate authentic hands-on learning experiences leveraging lesson plan activities from the NSTA LC, and have

students create their own digital resources collections to be discussed and shared via an integrated private online community forum, as well as a worldwide public discussion forum network that is linked directly from the course's landing page. Assignments or other coursework generated by pre-service teachers can also be shared amongst the course (such as samples of K–12 student work during their classroom practicums) using NSTA's digital PD Plan and Portfolio tool. In these instances, pre-service student participation is not voluntary, but autonomy is provided as they are allowed to make choices within boundaries, as they receive a course grade and graduate credit as prescribed by their professor. Below are mini-case studies that provide tangible examples how the blended models for professional learning are implemented by science methods professors using the NSTA LC for pre-service teachers.

Case 1: Indiana University-Purdue University Columbus

Dr. Kate Baird is a Clinical Assistant Professor in Science Education and uses the NSTA LC as part of a course titled "Methods of Teaching Natural and Social Science (MTNSS)." The experience takes place at a small rural-Midwestern undergraduate regional campus. The education degree offered is a B.S. in Elementary Education. Students enter as cohorts (10-20 students) after they have passed PRAXIS I and completed all their general education work before admission to the program. The MTNSS course is focused on supporting inquiry as a way to help K-3 students and teachers make sense of the world around them. *Designing Effective Science Instruction* (Tweed, 2009) and the NSTA Learning Center as texts.

The Big idea for the course is that Natural and Social Sciences should be inquiry-driven opportunities for sense-making based on standards linked to children generated questions. To achieve this outcome the course must: a) draw from many resources for lesson design and the flexibility necessary do build a student-driven inquiry-curriculum, b) facilitate a deep and readily

accessible understanding of content knowledge, c) enable a clear understanding of preconceptions of children, and d) empower and inspire teachers to demonstrate life-long professional growth. Students engage in three assignments to reach these course goals. They pre-assess content knowledge thought PD indexers and then demonstrate growth via a SciPack post-test; demonstrate understanding of known preconceptions through creation of a short instructional movie and field-based interactions; and professional growth through the NSTA Learning Center teacher portfolio tool. Regarding the PD Indexers one teacher candidate commented "The indexers were very challenging and somewhat aggravating at times due to I couldn't remember any of the answers from high school or didn't know them in general. Taking the indexers had shown me what things I remembered and what things I need to work on."

After completing this course teacher candidates express an increase in self-esteem as a result of this set of assignments and reference growth in useable science content knowledge (Table 1). Similarly, they expressed the importance of their growth in not only science content but also using technology to support learning. Citing the ability to address specific student needs through creation of instructional videos as well as what they learned from having the chance to view the videos of their peers. The knowledge that they can "use the NSTA SciPacks within their future lesson to support their instruction" is important to them as well. Students who have completed the first two blocks are now using the NSTA LC to support their student teaching. Hands-on experiences from class are being used in connection with science simulations the NSTA LC allow the student teachers to customize the existing classroom materials and resources. Comments from many of the teacher candidates mirror the following:

> "The information that I learned during the Plate Tectonics SciPack has been truly valuable. It took me ten-hours to complete the SciPack and I had to pass the final

test to earn the certificate. As an educator, gaining this deeper understanding about plate tectonics will help me to teach it in a way that is meaningful to my students. It was necessary for me to gain a deeper understanding to allow me to teach this subject with confidence. I look forward to sharing this new knowledge with my students."

"I plan on using activities that were mentioned in the SciPack as well as some that were discussed in the web seminar so my students have a better understanding of the topics and have fun while learning."

"I now feel more comfortable teaching students about rocks. Also, taking the SciPack made me realize some of the preconceptions students may have about rocks. Students come into our classrooms not with empty heads, but full of ideas of their own..."

Finally the NSTA LC digital teacher professional portfolio tool helps them begin to conceptualize themselves as teachers who will need to be life-long self-directed e-learners. Professional portfolios are now required as part of the local school districts teacher quality process. The candidates are very concerned with the changes in education and value tools from NSTA that help them find, excel and retain their jobs. This is especially important as the state moves to adopt "new" science standards in 2016.

Table 1

Examples of Pre-Service Teacher Growth in Science Content Knowledge

Term	Pre-Test Range	Post-Test Range	Average % Change
Spring 2013	10-54	60-80	22
Fall 2013	10-50	45-90	30
Fall 2014	30-70	58-90	29

Case 2: Florida International University

Dr. Kathleen Sparrow, Dr. George E O'Brien, and Jennifer Morales are from Florida International University (FIU) and use of the NSTA Learning Center as an e-text for the pre-service elementary science methods course for Pre-service teacher (PST) learning. This occurs in a blended approach which includes active learning, online interactive content learning, student-to-student interaction and application and practice in the field. The content driver for the 16-week course was sustainability which was framed and guided by the nine themes of sustainability literacy (Nolet, 2009). Their overall strategy engages PST's in an integrated environmental and science education approach (O'Brien & Sparrow, 2013). Their curriculum and instruction encourages active participation in real-world contexts and issues from which concepts and skills can be learned (NGSS, 2013; Sarkar & Frazier, 2010).

Four SciPacks (i.e., Coral Reef Ecosystems, Interdependence of Life, Flow of Matter and Energy in Ecosystems, and Resources and Human Impact) are selected for the environmental content to use in the course. Pre-service teachers select and complete one of these targeted

SciPacks from the NSTA LC as a central feature of their content resources. They then engage in a study group twice during the semester on their particular SciPack using guided questions from the professor. One of the foci in each of the selected SciPacks (and a Nolet (2009) theme) was the concept of system and a systems approach. As a result, using the PD Indexer tool as a pre- and post-assessment for the SciPack content, we found that three out of the four SciPacks showed highly significant content knowledge gains over time (<0.001). The fourth SciPack, Flow of Matter and Energy in Ecosystems, and Resources and Human Impact approached significance with a p=.058 (O'Brien, Sparrow, Morales, & Clayborn, 2014).

According to the research meta-analyses in the book *How We Learn* (2000) (Bransford et al., 2000), understanding science is more than knowing. Understanding science includes: a deep foundation of factual knowledge; an understanding of facts and ideas in the context of a conceptual framework; an organization of knowledge that allows for retrieval and application; inquiry procedures that help solve new problems; and transfer of knowledge from one context to another. Following these research findings, one of the projects that the professors designed was an ongoing study focusing on the concept that ecosystems strive to maintain a balance. Initially, PSTs watched a video of The Story of the Lorax (Geisel, 1972) in class and were instructed to pay attention to the characters and their relationships with each other. PSTs take notes in their science journals. After watching the video, PSTs, in small groups with their tablemates, discuss the characters and the role each play in the story.

PSTs are then given the challenge to create a concept map depicting the relationships between and among the characters in the Lorax story. The concept cards (pictures of all the characters) are drawn from the NSTA *Science Scope* journal article Teaching Science Through a Systems Approach (Llewellyn & Johnson, 2008), which PSTs read and may be accessed

digitally from the NSTA LC. The PSTs, working together as a small group, create a concept map of the relationships among the characters. The posters are displayed, and classmates move from table to table, describing the relationships their poster portrays. The PSTs then identify and apply what they learned about systems after watching a video titled How Wolves Can Alter Rivers (Monbiot, 2014).

In the subsequent weeks of the semester, many PSTs use this concept of balance in an ecosystem to develop (pre-assessment) interview questions to ask their field schools students' to gauge their grade level knowledge. Based on the interview data analysis, the PSTs design a 5E inquiry lesson which they taught to a small group of children and subsequently re-interviewed to analyze student learning and their own teaching. The design of this teaching, learning, and assessment project responded to the children's alternate conceptions in a way to help children overcome their learning gap.

Therefore, one of the major achievements for the PSTs is learning content from an NSTA Learning Center SciPack, subsequently exemplified by a children's story to relate the concepts of balance in a system; designed a 5E lesson to accommodate the students' learning level, actually taught their lesson with analysis of student learning and their own teaching. In addition to the results from the data analysis of SciPack usage and learning, the PSTs provide the professors with reflection and commentary captured via the NSTA Teacher Portfolio tool, which documents the profound impact in PSTs' motivation, interest, science content, and pedagogical content knowledge learning.

Case 3: University of Maryland, Baltimore County

Dr. Susan Blunck, Ph.D. is an Associate Clinical Professor Science Education in Science Education and uses the NSTA LC as part of a course titled The *Instructional Strategies for Teaching Science in the Elementary School* course at the University of Maryland, Baltimore County (UMBC). The course is designed to help pre-service elementary science teachers acquire holistic, interdisciplinary understandings of science and to develop a variety of developmentally appropriate rationales/strategies for teaching and assessing science in the elementary school. At UMBC, our pre-service elementary science teachers use the NSTA LC as their E-textbook where they access resources to boost their content understandings and help them gain insights into high quality professional learning experiences.

Teacher candidates in the course gain the knowledge, skills, and dispositions needed to design, implement, and evaluate developmentally appropriate science experiences for all elementary students. One of the main goals of the course is to help students become aware of high quality resources that will serve them during the course and across their careers as life-long learners.

Research shows us that elementary pre-service teachers are often weak in terms of their science content background. Once the UMBC students create a Learning Center account, they are able to have experiences with SciPacks, web seminars, e-book chapters, and journal articles, as well as, the professional development tools, such as the PD Indexer and Library, all designed to help them diagnose, track and boost content understandings and the habits of a true professional. In addition, students are encouraged to engage with other like-minded individuals in the NSTA LC online learning community by posting their questions and comments in the public forums.

The UMBC students visit the Learning Center where they work with the SciPacks in order to gain stronger content understandings to effectively design a two-week, inquiry-based, teaching module. The SciPacks serve as the main tool students use to gain deeper understanding of essential science concepts. Students select a SciPack title from the 25 available by diagnosing their knowledge of particular science concepts using the PD Indexer tool. While they work on the SciPack module outside of class, online interaction includes discussing instructional strategies with other educators via the public forums and internally sharing digital resource collections via the NSTA LC they've created that support their teaching of the two-week module. At the end of the semester students make these digital collections public and available to peers in the larger network.

The knowledge gained by the students using the Learning Center in this class is significant. Average pre/post assessment scores on the topic of the Solar System are 55.6%, for pre-assessments, and 67.8% for post-assessments, where the n=37. Students' self-efficacy has also increased. During class exit interviews, UMBC students shared the following feedback:

> "Knowing that all these resources exist in the NSTA LC boosted my confidence as a science teacher." "Interacting with other professionals helped me become more comfortable and confident about sharing my ideas and resources."
>
> "The self-directed aspects of the NSTA LC really appealed to me as a beginning teacher; it was comforting to know that these resources are here to use at any time."

Interestingly, 65% of the students declared that the use of the NSTA LC was "the best part of the class."

UMBC pre-service elementary science teachers and Dr. Blunck offer that they have benefited greatly from using the NSTA Learning Center in their class. As a science teacher educator, Dr. Blunck exclaimed "I am very excited about all the possibilities that lie ahead for us in future courses via the Learning Center. The NSTA LC is advancing a new paradigm for science teacher preparation and ongoing professional development."

We at NSTA are encouraged by this feedback and if desired, additional testimonials from other science methods professors from other universities and colleges are also available: http://learningcenter.nsta.org/impact/testimonials.aspx#College.

Balance of Science Content and Pedagogical Skills

As demonstrated by the narrative above, the NSTA Learning Center is not a professional development model in and of itself, but a platform with digital teacher resources, synchronous learning experiences, an integrated community network and recognition system, and a suite of personal diagnostic tools that may be configured for various methods of deployment whether it be for individual just-in-time, just-enough, just-for-me self-directed learning, or collaborative learning when integrated within a blended model of professional development through a group cohort. The Learning Center makes available our digital repository of 11,800+ digital assets and learning opportunities, which grows each month as more e-book chapters, web seminars and digital journal articles (lesson plans) come online.

Professional development appears most effective when it not only addresses teachers' beliefs and subject matter knowledge, but also increases pedagogical knowledge, that is, knowledge of how students learn (Council, 2005; Gess-Newsome, 1999; Pajares, 1992; Pomeroy, 1993). In an effort to provide this balance of content and skills, each SciPack also

includes a pedagogical object dedicated to the science content focus of that SciPack. We review the literature and identify for the teacher what science concepts are appropriate to teach by grade level, what are the known preconceptions related to the science concepts addressed in that SciPack, and what are the promising practices from the literature that may facilitate deeper student learning.

NSTA continually develops new digital press titles and online interactive learning based on demand. Examples include the NSTA e-book on *Hard-to-Teach Biology Concepts: A Framework to Deepen Student Understanding* (Koba & Tweed, 2014). Another popular NSTA series, *Uncovering Student Ideas in Science* (Keeley, 2013), focuses exclusively on formative assessment and making students think visibly in science. In addition, the *Picture-Perfect Science* lesson series (Morgan & Ansberry, 2013) is one that facilitates deeper student learning by coupling picture books and literacy with elementary science lessons and hands-on kits.

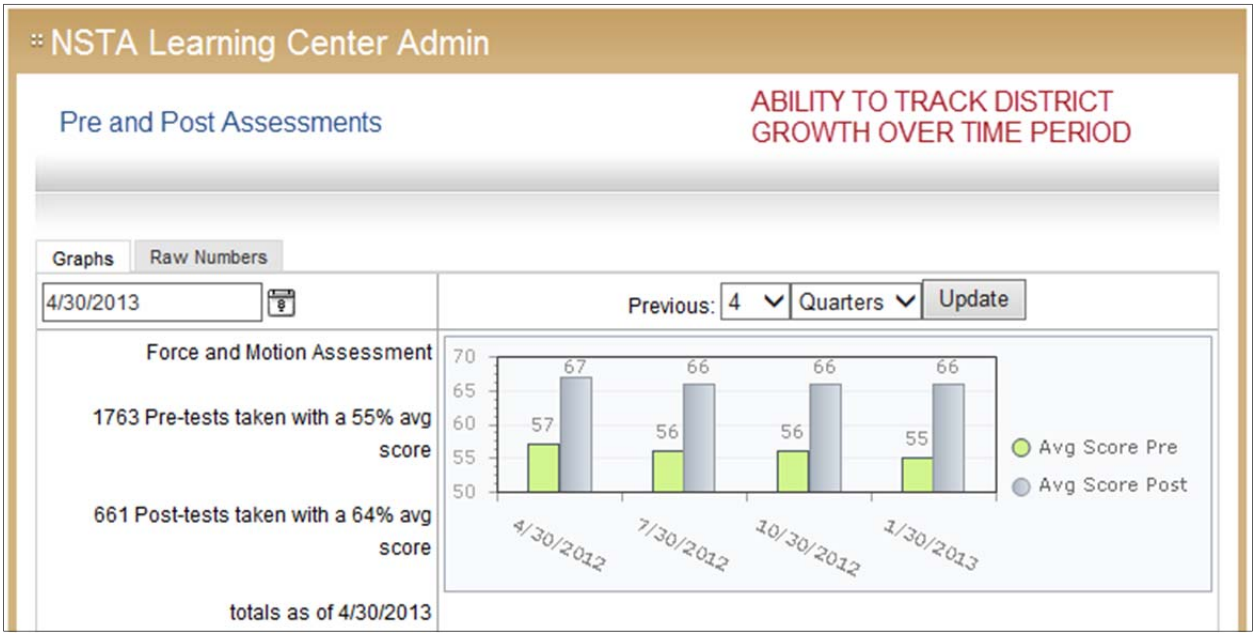
Ways of Ensuring High Quality

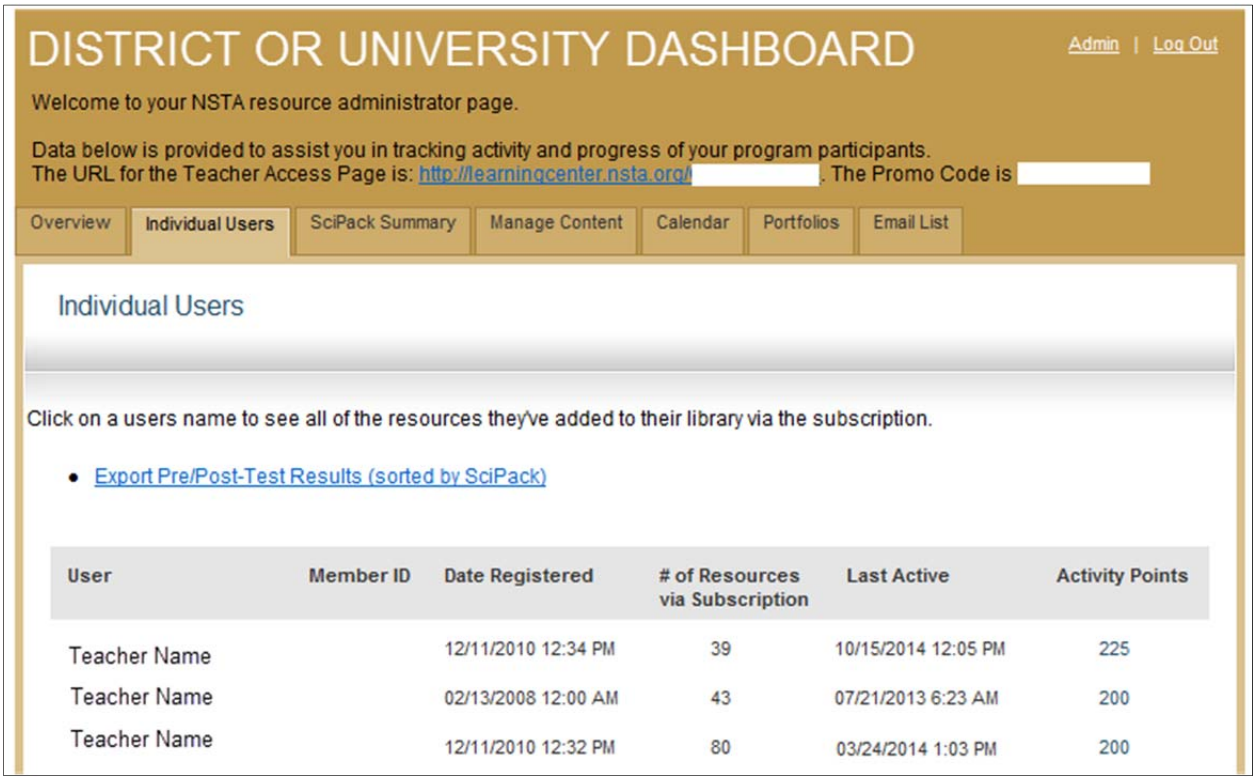
We take a consultative approach when working with a district or university cohort. We first engage professors and administrators in a series of discussions prior to deployment. The goal of these discussions is to identify the needs and desires of the organization and how PL experiences and other resources could be structured to meet those needs. We discuss integration strategies that are drawn from literature recommendations for a) achieving higher levels of learner engagement across a wide range of learners (del Valle & Duffy, 2009; Lowes, Peiyi, & Yan, 2007; Whitaker, Kinzie, Kraft-Sayre, Mashburn, & Pianta, 2007) b) enhancing understanding of subject matter knowledge and pedagogical content knowledge (Council, 2005; Gess-Newsome, 1999; Pajares, 1992; Pomeroy, 1993) and, c) empowering teachers through school-based (Fulton & Britton, 2011), or university collaborative learning. The intent of this is

to structure a blended learning environment with the greatest chance of end-user engagement, motivation, and applied learning. Once a plan is forged and the appropriate resources, tools, and opportunities are identified, we schedule a one-day, onsite orientation kickoff. This orientation provides an overview of our platform and can accommodate dozens of teachers, science department chairs, instructional coaches, principals, and science specialists. For smaller cohorts, the orientation can be attended via interactive web seminar. After orientation, NSTA follows-up with additional personalized web seminars, a help desk, a live chat system, email/phone support, and periodic performance reviews with the administrators and professors participating in a given district's locally delivered PL experiences.

Learners and administrators can also judge PL success using a wide array of tools that provide quantitative and qualitative reports (Figure 4). These reports are designed to assess both professional learning efforts relative to teacher subject matter knowledge acquisition, changes in classroom practice, and teacher contributions back to the district and/or university cohort. Professors and administrators can also track a wealth of information through web-accessible reports displayed on the administrator dashboard. These reports track both individual and group learning using pre- and post-assessments aligned with the SciPacks. It displays Scipack final assessment scores and digital reports, the type and number of resources the cohort is uploading and sharing, and their community activity across the entire group. It also displays teacher

reflections and samples of student work from newly-implemented changes in classroom practice.





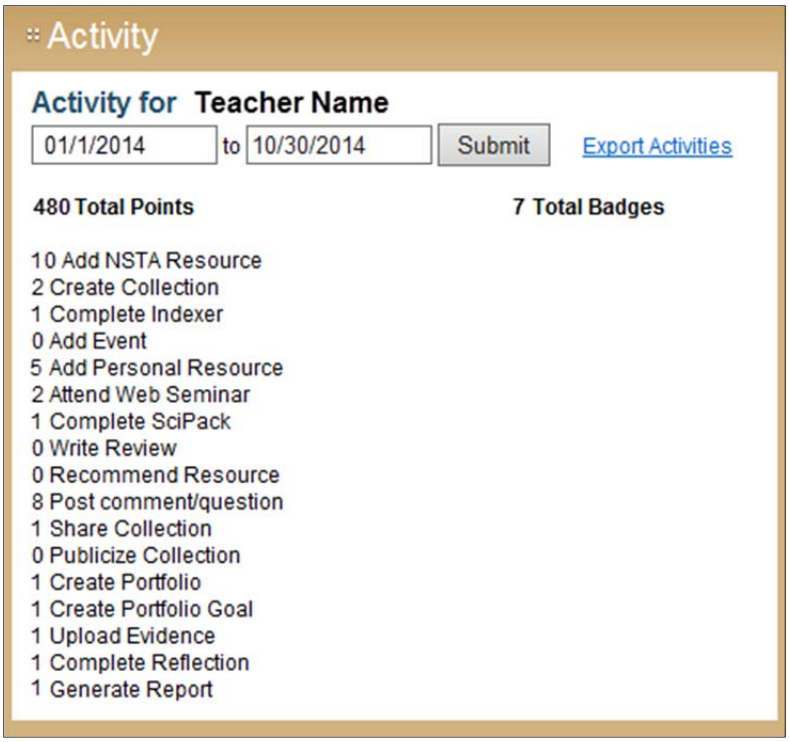


Figure 4. Examples of NSTA data reports accessible to administrators and university professors.

Research and Evaluation of NSTA Products

Over the last several years, multiple areas of research on the effectiveness of SciPacks have been funded by National Science Foundation (NSF), NASA, the GE Foundation, and the U.S. Department of Education. Past and ongoing research questions include: a) What components of our self-directed SciPack web modules are most effective?; b) Do SciPacks facilitate teacher knowledge acquisition?; c) How effective is the NSTA platform as part of a blended teacher knowledge acquisition model?; and d) What platform affordances facilitate effective online professional learning communities? (A. Byers, 2010; Cambridge & Perez-Lopez, 2012; Perez-Lopez, Cambridge, & Byers, 2012; Strauss, Bikson, Byers, & Karam, 2011; Strauss, Karam, Bikson, & Byers, 2013). In studies that evaluated the impact of SciPacks, teachers demonstrated significant gains in subject-matter knowledge and self-efficacy, across multiple

grade levels and subject matter areas (A. Byers, 2010; O'Connor et al., 2010; Sherman et al., 2008).

We diligently work to develop highly interactive content that embeds many levels of engagement and feedback for the teacher learner. This is coupled with the varied levels of social discourse previously described (e.g., discussion forums, live chat, email support, web seminars, and so on). We facilitate both science subject matter and pedagogical content knowledge in our online affordances to extend onsite experiences. Our findings, which are based on pre/post assessments, independent studies, testimonials, and growth trends, seem to lend credence to this approach (see: http://learningcenter.nsta.org/impact).

The Intended Model Versus the Enacted Model

Our current blended learning model was enacted to a) increase teachers' autonomy in their own learning, b) allow time for practice, observation, reflection and collegial discourse, c) administrator/instructor support, instructional guidance, and recognition of teachers' effort, and d) access to the necessary materials and technology to enact new teaching practices. To achieve these goals and fully enact our integrated blended learning model, NSTA needs to structure our professional learning opportunities after what is espoused in the K12 Framework for Science Education and the NGSS, as well as leverage strategies that recognize individuals' valuable investment in their own learning. We need to develop experiences that help teachers engage students in authentic challenges through hands-on scientific and engineering practices, and recognizing cross-cutting concepts to more deeply understand the disciplinary core ideas of science.

Working closely with district administrators and university professors in discussing how the NSTA LC tools, resources, and opportunities may be seamlessly melded into an on-going, integrated approach to learning and recognition of the same is critical to the effectiveness of our model and platform. Our resources need to be organized and structured in such a way that reflects these strategies of personalized growth and connectedness with others. If these components and a coherent strategy to integrate the online and onsite components do not work toward this end, ultimately, we are doing a disservice to those we are charged to serve.

We are making significant headway in this regard, and by employing various "freemium" business models, we can maintain, sustain and enhance the platform beyond any single grant. Individuals may freely access the portal with the over 4,200 free resources and do not need to be a member of NSTA. If they are a member, more free content is made available to them in the portal and member discounts apply for purchases for things such as books, or onsite and virtual conferences. If the NSTA LC is being deployed via a subscription model to districts, teachers access a large volume of content beyond the free content that include the SciPacks at no cost to them, as administrators pay the subscription, and secure access to the administrator dashboards to document teacher growth. Similarly, if a university cohort is using the NSTA LC as their e-textbook, a subscription model is also used, where pre-service teachers make the purchase for a specific course, and the professors gain access to the administrator dashboards to track teacher learning and community activity.

By the summer of 2015, a new NSTA LC will be deployed that will be responsive to different hardware accessing our portal (e.g., tablets and mobile phones), and improved connectedness between those in the open network that have like-minded interests and learning goals (e.g., similar resources in their libraries, web seminar attendance, and learning goals in

their digital PD Plan and Portfolio tool). Finally, we are encouraged with our recognition system that incorporates the use of badges (micro-credentials) and local leaderboards to affirm teachers' investment of their most precious non-renewable resource, their time. As one professor from the University of Texas shared:

> I have to admit that I was skeptical about the points/badges system working with my pre-service science methods students, but I was SO-O-O-O wrong! I simply put an announcement on Blackboard praising the top folks to date over the weekend. I didn't even think about the fact that the only man in one class had the overall top points. Several young women announced, "We can let Terry get away with that!" And so it began...The conversation went on for a while. I haven't met with my other class yet, but they too have upped the ante. I don't know what their reason is. I just know that a small group has infected the larger group. They know about their profile page, the leader boards, and the different types of Learning Center Activities in a way that will stick with them much better than my overview did.

Our badges cover a wide array of experiences where teachers may earn recognition in areas such as: a) serving on a national committee or advisory board, b) making contributions to our community forums, c) publishing articles in our journals or book chapters, d) aggregating and sharing digital resource collections via our forums, e) passing SciPack web modules, or f) completing learning goals in their personalized PD learning plans. A list of the current badges, levels, and point structures may be reviewed if desired: http://www.learningcenter.nsta.org/help/activity_awards.aspx. In closing, the NSTA Learning Center provides a system that begins to address the scale needed on a

national level to reach the existing 2 million in-service teachers of science in the US and the 50,000 new pre-service teachers that enter the profession each year through a platform that allows for personalized just-in-time individual learning and blended models via a structured way with cohorts across both districts and universities.

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