In Support of Access and Inclusion: Joint Professional Development for Science and Special Educators

Rita Brusca-Vega
Purdue University Calumet

Jan Alexander
Northeastern Illinois University

Colleen Kamin
Northeastern Illinois University

Abstract

Collaborative professional development of science and special educators leads to improved access and inclusion of students with disabilities. Yet, despite poor science achievement of students with disabilities, their increasing presence in general education science classrooms, and research that demonstrates effective teaching strategies for students with special education needs, there have been few reports of joint professional development in the literature. The purpose of the study was to examine changes in the teaching practices of science and special educators, grades 4 to 8, as they completed an intense year-long professional development program designed to promote hands-on, inquiry-based science in their classrooms and expand their instructional repertoires to better serve students with disabilities and other learning problems. Quantitative and qualitative measures, including pre and post ratings of teacher classroom performance, action research projects, and teacher self-reports were used to determine changes in teaching practices. Findings indicated all teachers showed improvement in the classroom on many elements related to classroom culture, instructional content, and lesson design and implementation, and the ability to adjust instruction.

Keywords

Joint professional development, collaborative professional development, teacher professional development, science teaching, disability, special education

Introduction

The Individuals with Disabilities Education Act calls for students with disabilities across the United States (U.S.) to have access to the general education curriculum and to be reasonably included in general education environments

Corresponding Author:
Rita Brusca-Vega, Associate Professor of Special Education, Purdue University Calumet, Hammond, Indiana.
Email: vegar@purduecal.edu

with their peers (IDEIA, 2004). Data from the U.S. Department of Education (2009a) indicate that students who receive special education services account for approximately 9% of the school-age population. Roughly 80% of these students spend 40% or more time in general education classrooms, following a trend of increased inclusion. Students with learning disabilities are most represented, but classrooms may also include students with intellectual disabilities, social/emotional disorders, sensory impairments, and physical or health disabilities. Details about students with disabilities in science classrooms, including their number, type of impairment, and how they are served, are unavailable. We can infer, however, that most science educators instruct a small percentage of these students and, subsequently, are responsible for classroom accommodations and modifications as indicated on the Individual Educational Plan (IEP). We can also infer that science educators will serve more students with disabilities in the future, accompanied by an increased need for interaction with special education colleagues.

In spite of greater inclusion in the U.S. and internationally, promoting the science achievement of students with disabilities has been largely overlooked. Schuelka (2013) has pointed out that major international assessments, including The Trends in International Mathematics and Science Study (TIMSS), actively exclude students with disabilities, a practice that serves to remove them from critical discourse on achievement and related educational policy decisions. The reasons for this neglect are, on the surface, easy to fathom. Students with disabilities comprise a relatively small percentage of students in general education science classrooms. Administrators, teachers, and parents may not expect these students to excel in science even under the best of circumstances. In addition, teaching basic literacy and math skills, managing behavior, and/or providing a life skills curriculum often takes precedence over content area instruction in subjects such as science and social studies. A deeper look at the importance of science education for students with disabilities, however, reveals that even benign neglect is damaging. Data from the 2009 National Assessment of Educational Progress show that the majority of students with disabilities, even with specified accommodations, fail to reach a basic level of science achievement, a situation that worsens substantially as students get older (U.S. Department of Education, 2009b). In the 12th grade, 75% of students with disabilities fell below minimum standards, up from 70% in 8th grade and 51% in 4th grade. Comparable scores for students without disabilities were 38%, 34%, and 26% respectively in grades 12, 8, and 4, showing a similar but far less dramatic pattern. For college students with disabilities, roughly 11% of the undergraduate population in the U.S. (Horn & Neville, 2006), lack of science knowledge and skill leads to risk of academic failure and diminishes their chances of obtaining employment and succeeding in science-related careers. There are also negative consequences for students with disabilities who do not continue in higher education. Lack of knowledge about science for daily living, such as eating for health and nutrition, conserving energy, and safely dealing with potential household hazards, has long- and short-term implications on quality of life concerns including independent living, wellness, and employment.

Improving the science achievement of students with disabilities is a doubtful goal without the combined effort of science and special educators. Science educators are the content and instructional experts in their subject area while special educators excel at using specialized and adapted techniques to suit the needs of individual learners across subjects.

Both types of expertise are needed to address poor achievement. In general education settings, simply including students with disabilities in science classrooms so they have access to the curriculum does not ensure that they will benefit from the content or the content expert. Instructional and/or curricular adaptations, with which science educators may not be familiar or may be unable to implement alone, are critical to success. In special education settings, students may have teachers who possess sophisticated understanding of their learning and behavioral needs but have limited preparation in science content and pedagogy. It is the rare science or special educator who can increase science achievement in special needs populations without the benefit of shared knowledge and skills.

Joint Professional Development Programs

A search of the research literature for professional development programs that jointly engaged science and special educators uncovered a small number of studies conducted over the past 15 years. Aspects common to all programs included a focus on instructional or curricular adaptations for students with either mild or more significant disabilities; practical, shared experiences with students with disabilities; and either the direct or indirect teaching of science content knowledge and instructional strategies (Bargerhuff & Wheatly, 2004; Cawley, Hayden, Cade, & Baker-Kocznski, 2002; Kirch, Bargerhuff, Cowan, & Wheatly 2007; Kimmel, Deek, Farrell, & O'Shea, 1999; Mutch-Jones, Puttick, & Minner, 2012; Van Garderen, Hanuscin, Lee, & Kohn, 2012). All but one program (i.e., Mutch-Jones et al., 2012) included a direct emphasis on science learning that was experiential, student-based, and reflective of national science education standards. Kimmel et al. (1999), for example, involved teams in traditional content and methodology-based workshops about math, science and technology and in an intensive, interactive summer practicum with students with disabilities. Cawley et al. (2002) required teams to participate in and prepare hands-on science learning activities during training and then return to their inclusive classrooms to apply an experiential science perspective along with a plan to enhance the science programs at their sites. Bargerhuff and Wheatly (2004) and Kirch et al. (2007) provided intensive summer residential experiences for teachers where time was devoted to content on disability, adaptive technology, and standards-based science instruction followed by practical experience working with students with sensory and physical disabilities in lab environments and follow-up contact and support when teachers returned to their schools. Van Garderen et al. (2013) emphasized universal design for learning in a summer institute and practicum. Teachers were required to examine barriers and solutions to accessibility and engage in a learning cycle model about science content that could be easily generalized to classroom practice. Mutch-Jones et al. (2012), however, developed knowledge about science content and instruction informally through teacher discourse about science lessons rather than through direct instruction. In this program, the only report of a randomized control study, science and special educators were engaged in lesson study, a professional development methodology from Japan that emphasizes a collaborative approach to planning and understanding lessons and anticipating student responses. Content on learning disabilities was presented directly to teachers along with training on lesson study procedures. Teachers practiced lesson study with summer school students and then continued with project support during the academic year.

Qualitative and quantitative data collected by program investigators in the above studies pointed to pre-to-post changes favorable to students with disabilities. These changes ranged from specific instructional practices and personal knowledge of teachers, such as switching from traditional assessment of science learning to performance-based measures (Kimmel et al., 1999) and the ability to generate multiple accommodations for students with learning disabilities (Mutch-Jones et. al, 2012), to broader curricular and instructional practices such as implementing student-centered, inquiry-based instruction within a co-teaching model (Cawley et al., 2002). With regard to student performance, concept development was judged to be greater following the implementation of hands-on, inquiry-based science teaching (Kimmel et al., 1999). In the Cawley et al. (2002) study, students with behavioral and learning disabilities passed the district science test at the same rate as their classroom peers without disabilities and did not present behavior problems in the co-taught science classroom.

In these studies, investigators also mentioned increases in teacher confidence in adapting instruction and willingness to persist in problem solving (e.g., Bargerhuff & Wheatly, 2004; Kirch et al., 2007; Kimmel et al., 1999) and transformations in many science classrooms, including the success of experiential science with students with autism (Van Gardener et al., 2012). Concerns included the ability of teachers to continue to apply their new knowledge and skill in typical environments following the training (Cawley et al., 2002; Kimmel et al., 1999) and, in one study, the apparent lack of increased knowledge of science content and learning disabilities despite increases in the ability to adapt lessons (Mutch-Jones et al., 2012).

Teaching Science to Students with Disabilities

Information essential to building joint professional development programs comes from the growing body of literature on teaching science to students with mild disabilities. A number of studies have demonstrated that curricular approaches featuring hands-on and inquiry-based experiences, rather than traditional textbook or other approaches, result in superior outcomes for students with disabilities, presumably because barriers to reading are reduced, concrete experiences enhance conceptual development, and students benefit from discourse with their peers (e.g., Aydeniz, Cihak, Graham, & Retinger, 2012; Lynch et al., 2007; McCarthy, 2005). An inquiry-based approach was also reported to be successful in inclusive science classrooms where science and special educators engaged in co-teaching (Brusca-Vega, Brown, & Yasutake, 2011). Another focus of research has involved adjusting science materials, curriculum, and instruction to better meet the individual needs of students with disabilities. Successful adjustments have included teaching students to use various learning tactics such as strategic note-taking during science lectures (Boyle, 2010) and graphic organizers for improving science vocabulary and factual comprehension (Dexter, Park & Hughes, 2011); making changes to print material such as altering readability levels with technology supports (Marino, Coyne, & Dunn, 2010); and using peer tutors in inclusive classrooms (McDuffie, Mastropieri, & Scruggs, 2009). For students with learning disabilities, the effectiveness of mnemonic instruction and structured inquiry-based environments was shown in a recent meta-analysis (Therrien, Taylor, Hosp, Kaldenberg, & Gorsh, 2011). An instructional theme to guide joint professional development, based on conclusions by Gersten and Baker (1998) and

Scruggs and Mastropieri (2007), is that improving science performance in students with disabilities can best be achieved by combining a special education oriented direct/explicit instruction model and cognitively-based approaches.

Purpose and Context of the Study

Using a mixed methods case study approach, we followed teachers during an intensive, year-long joint professional development program. We were especially interested in studying how the program affected two aspects of teacher change: specific classroom instructional behaviors and the ability of teachers to plan and execute interventions in an action research framework. The three-year funded project was conceived in response to a call for proposals by the Illinois Board of Higher Education to improve the quality of math and science teaching in the state. The goal of the Learning Together Program was to enhance the instructional skills of science and special educators who, in turn, would improve outcomes for the diverse, urban students they served. Four tenets support the philosophical framework of the program: (1) Students with and without disabilities are responsive to instructional practices that are student-centered, experiential, cooperative, and differentiated to meet individual needs; (2) Students with disabilities benefit from instruction in science and should have access to the general education curriculum and well-prepared teachers; (3) Students with and without disabilities share commonalities in their learning difficulties, including problems with attention, memory, and language, and these commonalities should inform teacher practice; (4) Curricular content and instructional delivery improves when science and special educators share their expertise.

Specifically, the program focused on shaping teacher practices to reflect (a) reform-minded changes in science teaching beneficial to diverse learners, e.g., a student-centered, inquiry-based, experiential approach; and (b) the use of specific strategies and adjustments to meet the needs of students with mild disabilities. The design of the program was informed by research demonstrating key elements of effective professional development, including a focus on core content and modeling of instructional strategies, opportunities for participatory learning and collaborating with other educators, and embedded follow-up and feedback (see Archibald, Coggshall, Croft, & Goe, 2011). The program featured integrated science content, reform-based science teaching methods and special education instructional strategies; joint presentations and modeling by science and special education experts; applied classroom activities including action research projects; classroom consults; and planning time for science-special educator school teams.

The action research component of the program was included as part of the applied activities to enhance teacher acceptance of and commitment to the program's philosophy and to provide teachers with skills to address instructional problems. According to Zeichner (2003), studies where action research has been used for professional development and examined systematically indicate that the process is transformative and energizing, making teachers proactive problem solvers and helping to create a culture of inquiry among participants. In this program, action research was introduced to teachers and then conducted as the culminating professional development activity with feedback and support from participants and project staff.

Participants

Recruitment

Recruitment efforts were directed toward Chicago area school teams of science and special education teachers who served students in grades 4 to 8, including those with disabilities. School and teacher participation was voluntary. Teachers received a stipend at the end of the professional development period, and their schools received funds to purchase science materials. The program was designed to include approximately five schools and twenty teachers each year of the three-year project period.

Schools and teachers

Across the three-year project period, sixteen K-8 schools from the Chicago metropolitan area were represented in the program, including four schools that served only students with serious emotional and behavior problems. Five schools served a predominantly African-American student body, five schools served a predominantly Hispanic student body, and the remaining schools served an ethnically diverse population. The majority of schools reported that roughly 70% to 99% free lunch eligibility. A total of 58 teachers from these schools participated in the program. The group represented a wide range of ages and years of experience, from beginning teachers in their early 20s to seasoned veterans in their 50s. All but two of the teachers were appropriately certified for the grades and subjects they taught. Approximately three-quarters of the group were female. Caucasian teachers comprised approximately 65% of the group followed by African-American teachers at 20% and Hispanic teachers at 15%. The number of teachers on a team ranged from two to nine, with most schools sending teams of four or five members. Of the 58 teachers, 30 were general educators and 28 were special educators. Approximately 20 of the general educators were assigned to mostly self-contained classes and were responsible for teaching science, math, and other subjects. Of the remaining general educators, five taught primarily science and five taught primarily math in departmentalized settings. The majority of the special educators were involved in teaching science and math to students with disabilities in several ways. They taught small groups or individual students in self-contained and/or resource settings and/or acted as consulting teachers to general educators who had students with disabilities included in their classrooms.

Professional development providers and setting

Professional development activities were conducted primarily by university faculty and staff representing earth science, physics, chemistry, science education, and special education, with assistance from museum educators from Sci-Tech Hands-On Learning Center in Aurora, IL and the Shedd Aquarium in Chicago. All providers had extensive experience teaching pre-service and/or in-service teachers. Activities took place at the museums, local schools, and the university's professional development center.

Structure and Content of the Program

During the school year, the teachers participated in a professional development course, which included the completion of action research projects, classroom consults, in-school team meetings, and cross-school meetings. During the summer, they participated in a four-day institute.

Professional development course

Instructional Strategies for Diverse Classrooms was a three-credit hour graduate level course devoted to science content and process appropriate for upper elementary and middle school grades and to inclusive teaching methods. Approximately ten broad topics were addressed throughout the course, each completed over one or two class sessions. Topics included inquiry-based instruction, differentiated instruction, waste reduction and the environment, properties of water, bio-diversity and water quality in the Great Lakes, magnetism and electricity, measurement and packaging, and the selection and adaptation of science curriculum materials. A unique feature of the course was the pairing of science content and inclusive teaching strategies within sessions, typically co-taught by a content expert and an instructional expert. For example, in the session on electricity and magnetism, the science expert led the teachers through an inquiry-based activity on electrical circuits followed by a review and clarification of concepts. The instructional expert then modeled how to facilitate understanding and retention of the concepts by using a re-tell strategy. In re-tell, students repeat their understanding of the concept to each other, usually in small groups or pairs, as others listen and provide corrective feedback. Teachers then practiced this strategy and discussed how it could be used in their lessons. Teachers were typically assigned homework that consisted of activities such as planning or delivering a lesson using the content and/or strategies learned in class. These were shared and discussed in sessions that followed. If the teachers did not possess the necessary materials for the lessons, they were lent or given to the teachers to use. The course took place over the academic year and consisted of 17 two-to-three hour sessions with the final three months devoted to supporting teachers in the development and implementation of action research projects.

Action research projects

The last two formal sessions of the professional development course were devoted to providing an overview of classroom action research to teachers, presenting samples of action research conducted by teachers that appeared in the literature or had been completed by previous program participants, and discussing ideas. Teachers had approximately three months to plan and complete the projects so that they could present their results at the final cross-school meeting of the academic year. Written narratives of the projects were required to include descriptions of the problem, literature related to the topic, research methods and intervention, results and concluding remarks. Teachers could complete individual projects or work in pairs or teams. Depending on their topic of interest, teachers were paired with project staff who mentored them throughout the project development. These interactions occurred by e-mail and/or in-person at the local schools or the university center.

Other program components

Over the academic year, teachers were also engaged in in-school and cross-school meetings and classroom consults. Teacher teams met at their schools at least twice monthly to engage in reflection about their instructional practices and student achievement. Teams were required to set goals, write and submit summaries of their meetings, and keep track of progress on issues identified for improvement. Teachers also met at the university center for cross-school meetings at least twice during the academic year so that teacher groups from different schools could share their perspectives and experiences. Consulting services of science and special education experts were made available to teachers. For the first cohort, these services were provided only when teachers requested them and usually consisted of an observation of a science class by an expert and one or more consultation sessions. For the two remaining cohorts, based on feedback from the experts and teachers, consultations with science experts were required and a modeling component was added. For example, a science expert would make an appointment with a teacher and model a hands-on, inquiry-based lesson appropriate to the grade and curriculum, such as a lesson on surface tension. The expert would then consult with the teacher about how to develop these practices in his or her own teaching and act as a resource in the development of their action research projects.

In the summer, a four-day institute was held at the university center and at participating museums. The institute served to reinforce and follow-up on course concepts and provide time for in-depth exploration of topics. Topics included co-teaching and differentiating instruction. At the request of the teachers, sessions on hands-on math for middle school students were included because teachers were interested in incorporating more math into their science teaching to improve students' ability to measure and interpret quantitative data. The institute included experiences to illustrate to teachers how local resources could be utilized to enhance science learning. For example, science educators at the Shedd Aquarium facilitated a water-testing activity for teachers in nearby Lake Michigan that teachers could replicate with their students. Teachers also used time at the institute for reflection and planning for the upcoming year.

Sources and Collection of Data

Two primary sources of data were used to examine changes in teacher practice through a mixed methods case study. First, classroom observations were conducted to document changes in instruction. Two formal observations of teachers in the first and second cohorts were conducted, one before and one after the professional development program. Each observation was conducted over the course of the science period, usually 45 to 55 minutes. The observation tool used was an edited version of the Reformed Teaching Observations Protocol (RTOP) (Sawada et al., 2000). The RTOP was chosen as a model because the items included desired instructional practices in science and math, including experiential and inquiry-based instruction, as well as instructional practices consistent with inclusive teaching, including student-centered learning and a climate of respect. Items were rated on a scale of 0 (never occurred) to 4 (very descriptive or characteristic of the lesson). Observations were conducted by a single observer who was prepared and monitored by the project's evaluator using the RTOP Training Guide. The observer, a retired, experienced teacher, described the lessons in narrative and then completed the numerical ratings. Second, action research projects were collected and examined qualitatively for evidence of self-reported change in teacher practices and improvement in student achievement and/or behavior in the context of desired instructional practices listed in the RTOP. Additional sources of data included monthly in-school meeting summaries submitted by teacher teams, pre/post teacher self-reports on instructional and school practices, annual feedback surveys, telephone follow-up interviews with teachers conducted the year after teachers completed the program, and semesterly staff progress reports. These sources were examined throughout the project to respond to concerns and make improvements and to better understand the collaborative process of school teams, classroom and school changes initiated by the teams, and teachers' personal perspectives of change.

Findings

Changes in Teacher Practices

Teacher classroom behavior

Observations conducted prior to the start of the professional development program showed several variables to be characteristic of the participants' classroom instruction (average ratings between 3 and 4): a climate of respect, encouragement of active student participation, active engagement of students in the lesson, and teachers who showed a firm grasp of the subject area. Other variables, including connecting lesson content to other disciplines or previous learning, having students make predictions and estimations, and allowing students to communicate their ideas in various ways were not commonly seen (average ratings between 1 and 2). Observations conducted after the professional development program showed that lessons had changed to better reflect "reformed" instruction, including increases in teacher patience, lessons that involved fundamental concepts, and allowing adequate time and structure for varied learning styles. (See Figure 1.) A two-way analysis of variance (ANOVA) was conducted for each of the 19 variables to determine the effect of the program on the combined group of teachers and to determine differences, if any, between general and special educators. (See Table 1). Most notably, the analyses showed that teachers significantly improved their ability to teach in reformed ways on all variables with the exception of one, "connected lesson to prior experience". This was also the only variable for which an interaction effect was found [$F (1,30) = 4.70, p < .0382$], with special educators making greater improvement than general educators. In post observations, the observer noted more examples of hands-on instructional activities such as experimenting with ways to extinguish fire, making DNA models, and constructing circuits. This was especially true for special education classrooms. The observer also noted that teachers incorporated more collaborative learning into instruction and asked questions of students that required them to engage in more planning, executing, and explaining.

Fig. 1. Pre and Post Teacher Observation Ratings on RTOP Items

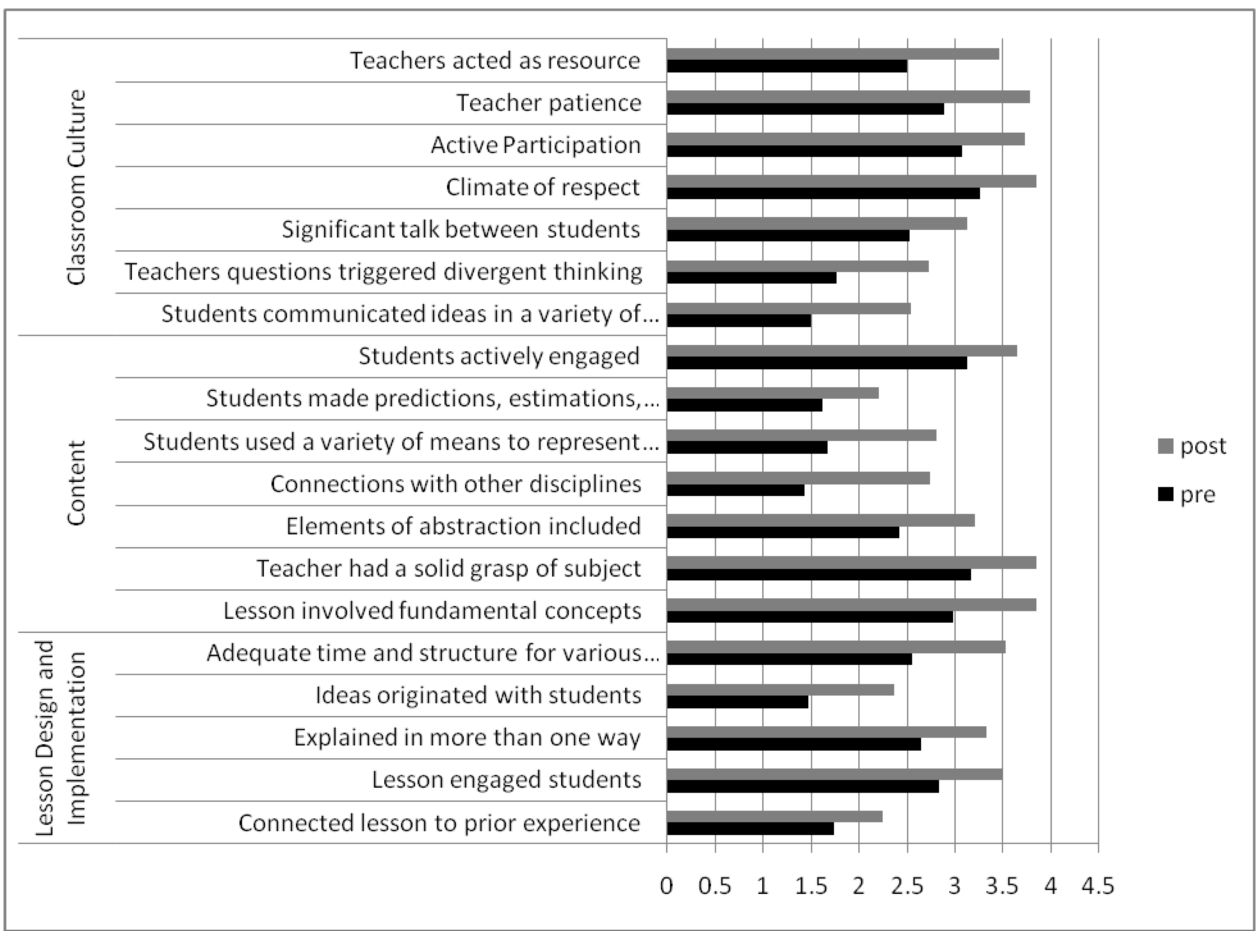

Table 1. ANOVAs for Pre and Post Teacher Observations on RTOP Items

Item	df	MS	F	p
Classroom Culture				
Teachers acted as resource	30	17.73	17.57	.0002
Teacher patience	30	10.76	37.15	.0001
Active participation encouraged and valued	28	5.53	14.93	.0006
Climate of respect	29	4.41	11.57	.0020
Significant talk between students	29	7.34	5.00	.0332
Teachers questions triggered divergent thinking	30	13.30	9.57	.0043
Students communicated ideas in various ways	31	19.32	11.71	.0018
Lesson Content				
Students were actively engaged	31	4.00	10.36	.0027
Students made predictions, estimations, and hypotheses	26	7.66	4.36	.0466
Students used a variety of means to represent learning	29	26.48	13.89	.0008
Connections to other disciplines made	30	23.54	17.27	.0002
Elements of abstraction included	30	13.15	16.65	.0003
Teacher had solid grasp of subject	31	6.37	34.90	.0001
Lesson involved fundamental concepts	31	9.81	20.11	.0001
Lesson Design & Implementation				
Adequate time, structure for various learning styles	29	13.18	18.93	.0002
Ideas originated with students	29	12.35	8.32	.0073
Concepts explained in more than one way	31	7.04	10.96	.0024
Lesson designed to engage students as learning community	31	6.59	8.64	.0062
Connected lesson to prior experience	30	4.24	3.84	.0593

Teacher use of interventions

The action research projects provide a deeper look at changing teacher practices. Roughly two-thirds of the projects were completed by individual teachers with the remaining third completed by teams of two or three teachers. Project topics included co-teaching arrangements between the science and special educator; increasing hands-on experimentation; creating learning stations; implementing self-monitoring strategies to improve academic and social behavior; and redesigning a science unit to incorporate activities from each of the multiple intelligence areas (e.g., kinesthetic, musical, visual). In their reports, teachers demonstrated that they thought carefully about the relationship of student characteristics and instructional strategies and how the instructional environment could be manipulated for desired outcomes. The three examples presented here show how a special education teacher (Crystal) began to use an experiential science approach to improve class grades and behavior; how a general education science/math teacher (Diane) incorporated cooperative learning as a means to support student efforts; and how a science teacher and a special educator (Gabriela and Damaris) used collaborative reading and a note-taking strategy to support science literacy with an inclusive class of English learners.

Crystal's project. Crystal, a certified K-12 special educator, taught in a special school for students with severe emotional disturbance and was responsible for all subject areas for a small group of 7th and 8th graders. She taught science three days a week for one hour in her small classroom, which was not equipped as a lab. Science was scheduled at the end of the day and she sensed that one of the reasons for poor behavior and grades in her class was a combination of fatigue and her traditional science teaching methods. She conducted a student survey and decided to make some changes:

> After providing a questionnaire, many of the junior high students found science to be boring compared to their other subjects. Reflecting on the questionnaire, I agreed with them. Although I could not change the other science classrooms, I began to think about the changes I needed to make. Regardless of the exhaustion that sets in at the end of the day, it was my responsibility to spark their interest the whole day. ... With the use of graphic organizers and highly structured hands-on experiments weekly, I hoped that my students would learn science is related to them and that science can be fun. My goal was for each student to decrease negative behaviors during science and change his/her perception of the class. With that, students would be able to actively be engaged in the class and their overall grade would increase.

Over the next quarter, Crystal worked with her students on understanding scientific practices and conducting experiments. She divided the quarter into two-week mini-units and had the class select science topics and experiments. Each unit included activities that linked the new topic to prior knowledge, reading and discussion about the topic, taking turns at leading activities, and hands-on experimentation. At the end of the quarter, Crystal found that students earned 95% or more of their points for good behavior and academic work, up from approximately 75% from the previous semester in science. She was especially proud at the end of the unit when student surveys indicated that science had, in the words of one student, gone from "a crashing bore" to "fun and educational."

> This project helped me see the things I needed to improve during afternoon instruction. ...I learned that I did not have to work at a slow pace and that I needed to change my methods during Science. I needed to provide my students the opportunity to act appropriately during experiments, as I provide a well-structured atmosphere. Allowing the students to provide their input on what they wanted to learn also helped out.

Diane's project. Diane was an experienced 4th grade teacher who taught departmentalized math and science classes where students with disabilities were included. Peer-assisted learning was not something that Diane had incorporated into her teaching, so she chose to adapt a mini-unit on surveys and graphing that her previous students often had a hard time completing independently. Diane divided the students into pairs, spent time teaching roles and responsibilities of partners, and gave students a concrete four-step process to guide them through the project. She was apprehensive about possible conflict between students and wasn't sure what the students with disabilities would be able to add to the learning process:

> For the most part, my students are seated in groups, but don't always have the opportunity to work together on a project, so this was a big change for them. Right from the start the students were excited, especially when allowed to circulate among peers to survey and collect data. As I observed, I paid particular attention to my special education students. I was careful to select just the right partner for them, and watched to see they were given the same opportunities to complete parts of the activity that they would be capable of doing. Recording tallies on the survey chart, filling in the data on the frequency table, coloring in the bars on the graph were perfect for them. They seemed to really feel as though they were being treated as equals, with equal responsibilities. It was great seeing such a high degree of team work and peer collaboration.

Project staff perceived Diane as thorough and concerned but reluctant to try an approach where she would need to relinquish some control of the classroom. By the end of the unit, Diane seemed much more comfortable with the idea that students could learn from each other and behave in responsible ways and planned to use more peer-assisted learning in the future:

> By Day 3, the students had completed their graphs and were now able to write up their questions. The students were so interactive with this part of their assignment. They really put their "heads together" to come up with creative, challenging questions. ...After the groups finished their questions, they were ready to test their peers. I assigned group pairings to avoid chaos. The two groups would then go off into a secluded part of the classroom and attempt to answer the questions. The groups then came back to share their answers. This was a sight to see. True peer collaboration was happening right in front of me.

Gabriela and Damaris's project. In this project, a science teacher and a special educator who were both Spanish-English speakers initiated co-teaching and literacy strategies to improve the science learning of a 5th grade class of 31 English learners, including seven students with disabilities. The teachers received permission from the principal to re-arrange class schedules so they could co-teach and extend the usual 40-minute science period into a 60-minute period to provide more time for literacy instruction within science. They incorporated collaborative reading and a note-taking strategy in a co-taught unit on astronomy. Instruction was conducted primarily in English with support in native language. Reading materials were available in both languages. Teachers took turns leading the lessons and working with students in small groups. Adjustments for students with disabilities were made primarily for the end-of-unit presentations. Peers assisted students with disabilities by acting as scribes and students were encouraged to make liberal use of pictures and captions during their presentations. Scores on the unit assessment improved for all students. The teachers then presented their project and examples of student work to the rest of the school staff as a model for others. As bilingual teachers interested in supporting language as well as science development, they were especially pleased with increased student participation:

> We observed student interaction through the unit, and noticed that the levels of interaction for bilingual students with and without IEPs increased noticeable. Since the books were at their reading levels, and in some cases in their native language, these students were now able to fully discuss and participate in the discussions. Their participation included illustrations, computer research, and so on. Since this was based at their pace and level, the students were then able to research their topic and present their information to the class comfortably.

Other changes

End-of-project self-reports by teachers indicated a greater repertoire of instructional adjustments that could be made for students with disabilities. Teachers in the first cohort, for example, provided a limited list of adjustments prior to the project, consisting primarily of modifying tests, giving shorter assignments, and using peers. They ended the project with an extensive list of adjustments that included using technology (e.g., calculators, computers), incorporating pictures and visuals, breaking down concepts, allowing additional time for assignment completion, selecting reading materials at the student's reading level (rather than grade level), and re-arranging instructional time for small grouping or one-to-one instructional time with the teacher. There was also evidence that teachers came to value collaborating with peers as a result of the project and increased their knowledge as a result of the interactions. Prior to the project, teachers reported a low and/or inconsistent frequency of collaborative time for teachers of the same grade or subject area and few special educators reported being included in any collaboration activities. Meeting minutes showed that most teams used their time to share experiences with new instructional techniques (e.g., self-monitoring strategies, concept mapping), and/or solve problems related to one or more students (e.g., ideas for math manipulatives for a student with a learning disability). Teams also examined general areas of concern or interest to teachers (e.g., What makes reading in science difficult? What comprises high quality instruction?), sometimes assigning a reading on the topic prior to the meeting for discussion. Follow up interviews revealed that some teams and team members voluntarily continued to meet after the project period because of collaborative projects they had started to implement and because they found collaboration to be professionally and personally beneficial.

Conclusion and Discussion

The teaching practices of the science and special educators described in this case were positively influenced by the multidimensional year-long professional development process. First, teachers significantly improved their ability to teach in ways reflective of research-based and contemporary ideas about science instruction across the rating categories: classroom culture, content, and lesson design and implementation. Yet, in each category, there were characteristics of reformed classrooms and teaching that, while improved, were not well-manifested. These included student-initiated ideas, student predicting and estimating, and student communication of ideas in a variety of ways. Had program staff observed classroom teaching more often during the school year, these weaker aspects of the teaching and learning science environment might have been addressed by activities such as modeling or lesson planning. Second, teachers showed that they could plan and implement interventions, including adjustments to instruction, for a diverse range of students. Student achievement was not directly assessed in this project, but results of the teacher action research projects showed that newly implemented instructional strategies had a favorable impact on academic performance for students with and without disabilities. Combining science and special educators appeared to help create an interactive environment that was mutually beneficial, with members of the school teams supporting each other in their endeavors. Pairing content with differentiated instructional strategies and providing opportunities for hands-on practice and the exchange of ideas and experiences appealed to both groups: general educators seeking to address state standards with a diverse student population and special educators with responsibility for teaching the content themselves in self-contained settings and/or in collaboration or consultation with their general education counterparts.

One challenge to the project was the lack of participation by school principals. An original intent of the project was to support long-lasting change by having school principals invested in this goal. They were informed about expectations for attending cross-school meetings and being an important part of the team, but few participated. Most principals appeared to view the project as personal development for the teachers rather than as a way to affect school-wide change. In follow-up interviews conducted with teachers, there was evidence of continued change in their practices but only a few examples of how the project had changed or benefitted the science, math, or special education programs across the school. These exceptions included two schools in which teachers reported initiating co-teaching as a regular practice in the science and math classrooms as a result of their experiences in the project, and one school where project teachers volunteered to be the first to pilot a district inclusion initiative. In retrospect, required introductory group meetings with the principals and district administrators responsible for science and special education services prior to acceptance of the school teams into the project may have maintained interest and helped principals see how the project goals might interface with school goals. Having principals participate in the development of ideas for the action research projects may have been another way to influence whole school change.

The dearth of joint professional development programs for science and special educator school-based teams is disappointing considering the positive changes that have been reported in this study and previous programs (Bargerhuff & Wheatly, 2004; Cawley et al., 2002; Kirch et al., 2007; Kimmel et al., 1999; Mutch-Jones et al., 2012; Van Gardener et al., 2012). This is not to say that educators are intentionally excluded from professional development outside their respective fields, but that the focus of typical offerings is not on building a common knowledge and skill base. What seems critical to the development of a joint skill base is the opportunity to practice in typical environments and, especially, the opportunity to practice together. In this study, as in the Cawley et al. and the Mutch-Jones et al. studies, the requirement that educators take what they have been taught and apply it in their science classrooms is an indispensable component of the change process. Action research that is supported and shared in the school or district, and collaborative processes such as lesson study, appear to be viable choices for accomplishing change with joint audiences. An effective plan would harness the power of teaming in program delivery and participation and the power of collaborative applied practice.

References

Archibald, S., Coggshall, J.G., Croft, A., & Goe, L. (2011, February). *High-quality professional development for all teachers: Effectively allocating resources.* (Research Brief). National Comprehensive Center for Teacher Quality.

Aydeniz, M., Cihak, D.F., Graham, S.C., & Retinger, L. (2012). Using inquiry-based instruction for teaching science to students with learning disabilities. *International Journal of Special Education*, 27, 189-206.

Bargerhuff, M. E. & Wheatly, M. (2004). Teaching with CLASS: Creating laboratory access for science students with disabilities. *Teacher Education and Special Education*, 27, 318-321.

Boyle, J.R. (2010). Strategic note-taking for middle-school students with learning disabilities in science classes. *Learning Disability Quarterly*, 33, 93-109.

Brusca-Vega, R. Brown, K., & Yasutake, D. (2011). Science achievement of students in co-taught, inquiry-based classrooms. *Learning Disabilities: A Multidisciplinary Journal*, 17, 23-31.

Cawley, J., Hayden, S., Cade, E. & Baker-Kroczynski, S. (2002). Including students with disabilities into the general education science classroom. *Exceptional Children,* 68, 423-435.

Dexter, D.D., Park, Y.J., & Hughes, C.A. (2011). A meta-analytic review of graphic organizers and science instruction for adolescents with learning disabilities: Implications for the intermediate and secondary science classroom. *Learning Disabilities Research and Practice*, 26, 204-213.

Gersten, R. & Baker, S. (1998). Real world use of scientific concepts: Integrating situated cognition with explicit instruction. *Exceptional Children,* 65, 23-35.

Horn, L. & Neville, S. (2006). *Profile of undergraduates in U.S. postsecondary education institutions: 2003–04*: *With a special analysis of community college students (NCES 2006-184).* U.S. Department of Education, Washington, DC: National Center for Education Statistics.

Individuals with Disabilities Education Improvement Act of 2004, 20 U.S.C. §1400 et. seq. (2004).

Kimmel, H., Deek, F.P., Farrell, M.L., & O'Shea, M. (1999). Meeting the needs of diverse student populations: Comprehensive professional development in science, math, and technology for teachers of students with disabilities. *School Science and Mathematics,* 99, 241-249.

Kirch, S.A., Bargerhuff, M.E., Cowan, H., & Wheatly, M. (2007). Reflections of educators in pursuit of inclusive science classrooms. *Journal of Science Teacher Education*, 18, 663-692.

Lynch, S., Taymans, J., Watson, W. A., Ochsendorf, R J., Pyke, C., & Szesze, M. J. (2007). Effectiveness of a highly rated science curriculum unit for students with disabilities in general education classrooms. *Exceptional Children*, *73*, 202-223.

Marino, M.T., Coyne, M., Dunn, M. (2010). The effect of technology-based altered readability levels on struggling readers' science comprehension. *Journal of Computers in Education and Science Teaching,* 29, 31-49.

Mutch-Jones, K. Puttick, G., & Minner, D. (2012). Lesson study for accessible science: Building expertise to improve practice in inclusive science classrooms. *Journal of Research in Science Teaching*, 49, 1012-1034.

McCarthy, C. B. (2005). Effects of thematic-based, hands-on science teaching versus a textbook approach for students with disabilities. *Journal of Research in Science Teaching,* 42, 245-263.

McDuffie, K., Mastropieri, M.A., & Scruggs, T.E. (2009). Differential effects of peer tutoring in co-taught and non-co-taught classes: Results for content learning and student-teacher interactions. *Exceptional Children*, 75, 493-510.

Sawada, D., Piburn, M., Falconer, K., Turley, Benford, R., & Bloom, I. (2000). Reformed Teaching Observation Protocol (RTOP). (Arizona Collaborative for Excellence in the Preparation of Teachers Technical Report No. IN00-3.) Tempe, AZ: Arizona State University.

Schuelka, M.J. (2013). Excluding students with disabilities from the culture of achievement: The case of the TIMMS, PIRLS, and PISA. *Journal of Education Policy*, 28, 216-230.

Scruggs, T. E. & Mastropieri, M. A. (2007). Science learning in special education: The case for constructed versus instructed learning. *Exceptionality,* 15 (2), 57-74.

Therrien, W.J., Taylor, J.C., Hosp, J.L., Kaldenberg, E.R., & Gorsh, J. (2011). Science instruction for students with learning disabilities: A meta-analysis. *Learning Disabilities Research and Practice*, 26, 188-203.

U.S. Department of Education. (2009a). *31st annual report to Congress on the implementation of the Individuals with Disabilities Education Act.* Washington, DC: Author.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP) (2009b). *NAEP2009 mathematics and science assessment data.* [Data files]. Available from the National Center for Education Statistics website, http://nces.ed.gov/nationsreportcard.

Van Gardener, D., Hanuscin, D., & Lee, E. (2012). QUEST: A collaborative professional development model to meet the needs of diverse learners in K-6 science. *Psychology in the Schools*, 49, 429-443.

Zeichner, K.M. (2003). Teacher research as professional development for K-12 educators in the USA. *Educational Action Research*, 11, 301-325.

About the Authors

Rita Brusca-Vega, Ed.D., is associate professor of special education at Purdue University Calumet where she directs the online special education graduate program. She is a former special education teacher and is an active advocate for students with disabilities who are learning English as a second language.

Jan LeDonne Alexander, Ph.D., is director of research & evaluation at the Center for College Access & Success at Northeastern Illinois University in Chicago. She is a former special education teacher and principal. Her research interests include college access for diverse students and inclusive education.

Colleen Kamin, Ph.D., Ltd. has been working in grant evaluations for twenty five years. She uses both quantitative and qualitative approaches. She is currently collaborating with Northeastern Illinois University, Purdue University Calumet, the Chicago Symphony Orchestra, and Urban Gateways. Prior to this work, she taught foreign languages in the Chicago Public Schools.