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ABSTRACT

The purpose of this research was to explore two professional development models, Nevada Operation Physical Science (a three-weekend course) and Nevada Operation Chemistry (a two-week intensive course with a follow-up session in the fall), to see if there was any impact on learning and to determine the ideal length of the workshops as measured by teacher efficacy and outcome expectancy on teaching physical science. The general effectiveness of the program and teachers' perspectives on usefulness were anecdotal components of the study to help with discussion. Although some differences did occur between the workshops, for all intents and purposes the length of the workshop became the experimental variable. Initially there was no difference found in outcome expectancy between the two models, although there was a significant change in outcome expectancy after the follow-up meeting four months later for Nevada Operation Chemistry. It is suggested that for professional development to be effective, more than an intensive workshop is needed. (Contains 20 references.) (MVL)

PROFESSIONAL DEVELOPMENT MODELS: A COMPARISON OF DURATION AND EFFECT

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Professional development has been a large part of the science education field for quite some time. Since the release of the National Science Education Standards (NSES) (1996), professional development in the form of in-service (or re-training practicing teachers) to meet both process and content science standards have burgeoned. The National Science Foundation (NSF) and much of the Dwight D. Eisenhower (DDE) money for higher education, as well as many other funding agencies and programs, have funded numerous national, statewide, and local programs.

With this increase in professional development have come scrutiny of previous professional development models. Traditional modes of professional development, "lectures to convey content and technical training about teaching" were criticized by the National Science Education Standards (NSES, 1996, p.56). Criticisms of professional development programs stem from as early as Karplus and Thier (1967), to numerous articles (Cook, 1994; Darling-Hammond & McLaughlin, 1995; Howe & Stubbs, 1997; Wallace, Nesbit & Miller, 1999), to entire books on the subject (Tobias, 1990; Mandy & Loucks-Horsley, 1999). Howe and Stubbs (1997) eloquently surmise the situation by stating:

> It seems clear that past and present methods and approaches to continuing professional development for teachers have not produced the desired result and that new methods and approaches are needed. If we continue to do the things we have always done, we will continue to have the results we have always gotten - and these results are not serving us well" (p.168).

The National Science Education Standards (1996) call for reform in professional development and "if reform is to be accomplished, professional development must include experiences that engage prospective and practicing teachers in active learning that builds their knowledge, understanding and ability" (p. 56). Although the NSES outline components that "Professional Development" programs should include, there is still a considerable amount of research in the literature on what and how professional development programs should be structured and conducted.

The literature reveals that many of the "new" forms of professional development have coincided with the rise of new programs such as Sci-Link (Anderson, 1993) , Project LIFE (Radford, 1998) and the GLOBE project (Pyke, 1999) to name just a few. Several models of professional development have been outlined as a result of these programs. Howe and Stubbs (1997) wrote about a constructivist/sociocultural model of professional development, Radford (1998) proposed a model of professional development in life sciences, and Wallace, Nesbit, and Miller (1999) wrote about six different leadership models in professional development that were developed by looking at 15 professional development programs over time in North Carolina. Additionally, several national organizations have recently made professional development a high priority and have been publishing books and information on professional development opportunities. The National Science Teachers Association (NSTA) has recently taken a lead in this arena and has set up a professional development network showcasing programs and offerings available from their website (www.NSTA.org). NASA has a unique "portable" approach to space education that they offer in a variety of locations for teachers. In addition, the National Science Education Leadership Association (NSELA) has recently published in concert with NSTA two new books edited by Rhoton and Bowers (2001). The first, *Professional Development:*

Planning and Design, and the second, *Professional Development Leadership and the Diverse Learner*. Both books are very informational and helpful in developing professional development programs.

All of these models have some commonalities; specifically, there was an intensive summer workshop ranging from two to three weeks, a project of some sort for the participants to work on, and academic year follow up. The programs included methodologies such as small group work, hands on activities, constructivist learning situations, and utilized scientists in the field content area of research. These are the components that good science instruction and professional development should include and are recommendations and/or suggestions advocated by the NSES (1996). Recently, the U.S. Department of Education (2000) released a three-year longitudinal study on professional development involved in the DDE program. It found basically no change in practice from teachers in the study. However, there were variances between teachers. When these variances were examined, they found that some professional development programs were more effective than others. The study identified "six key features of professional development that do improve teaching practice: Three structural features (characteristics of the structure of the activity) - reform type, duration, and collective participation - and three core features (characteristics of the substance of the activity) - active learning, coherence, and content focus" (p. 59).

Problem

For many years, professional development has been a large part of the science education community. Since the release of the NSES (1996), professional development in the form of in-service (or re-training practicing teachers) to meet both the process and content standards has intensified. The National Science Foundation (NSF) and much of the DDE money for higher education, as well as many other funding agencies and programs, have funded numerous national, statewide, and local programs.

The state of Nevada, like most other states, has recently written statewide science content standards, performance standards, and performance assessments requiring teachers teach certain concepts/topics by the benchmark grade levels. Performance tests for the children in their classrooms make teachers accountable for the science content taught. With this latest legislative action, some funding came from state appropriations in the legislative session, but the great majority of the retraining of the teachers still comes from entrepreneurial efforts related to diminishing funds from government agencies. With this influx of money and expansive base of initiatives, the question remains: Which workshops and programs with differing formats, and durations, of professional development, allows for the most productive results given the time constraints that classroom teachers already have with their busy schedules?

Purpose

The purpose of this research was to explore two professional development models, Nevada Operation Physical Science (a three weekend course) and Nevada Operation Chemistry (a two week intensive course with a follow-up session in the fall), to see if there was any impact on learning and the "ideal" length of the workshops as measured by teacher efficacy and outcome expectancy on teaching physical science. The general effectiveness of the program and teachers' perspectives on usefulness were anecdotal components of the study to help with discussion. In order to control variables, both workshops teach physical science concepts and were taught by the same instructors. Although some differences did occur between the workshops, for all intents and purposes the length of the workshop became the experimental variable. The population of teachers came from the same large county school district.

Program Description

Nevada Operation Chemistry

This research focuses on a national program that co-evolved with the Benchmarks, Project 2061, and the advent of the National Science Education Standards. Operation Chemistry (Op Chem) which was originally funded by the National Science Foundation (NSF) in conjunction with the American Chemical Society (ACS) was a five year effort that was designed to enhance the chemistry and chemical education literacy of teachers of grades 4-8 throughout the nation. Nevada Operation Chemistry, based upon the national Operation Chemistry model, is a program designed to enhance the conceptual and activity-related chemistry understanding of K - 8th grade teachers and pre-service teachers throughout the state of Nevada. Specific goals of the program are to (a) instill in participants a sense of confidence about their ability to learn and teach chemistry in a hands-on inquiry manner in accordance with National and State Science Education Standards; (b) foster professional growth, including presentation of content and methodology to peers in school, local, state, and national settings; (c) make participants aware of the relationship between chemistry in the school, university, community, and industry; (d) nurture the sense of community and collaboration among participants that is possible with an intensive, long-term program.

Nevada Operation Chemistry is a cooperative effort between the University of Nevada, Reno, College of Education, Chemistry Department, Biology Department and School of Medicine, Nevada State Department of Education (Science), Washoe County School District, Douglas County School District, Clark County School District, Humboldt County School District, Lyon County School District, The Nevada Rural Alliance, Newmont Gold Co., Cyanco, Eldorado Hotel-Casino, Brew Brothers, Nevada Mining Association, Women in Mining

Educational Foundation, and Sierra Nevada section of the American Chemical Society.

Nevada Operation Chemistry has been primarily funded by the DDE monies for higher education in the state of Nevada along with substantial donations from industry, businesses, and education associations totaling over $180,000.00 over the past three years and has trained more than 156 teachers.

The workshop is currently set up as a summer course where teachers are brought to the University of Nevada, Reno for a two week intensive workshop and field trip, a long term project/presentation to be made by the participant, and a follow-up workshop during the late Fall. Housing, per diem and mileage is provided for participants traveling from out of town. Tuition for graduate credit (3 credit hours) is paid by the program for all participants. In all, the two week workshop entailed 60 hours of formal instruction and a minimum of 11 hours of group discussion time.

The participants then go back to their classrooms and teach science adding Nevada Operation Chemistry activities to their current curriculum (which was part of the workshop of finding where and how the content and activities fit into their standards and curriculum). All the while they are working in teams of two to four in designing a professional development experience for teachers in their schools or districts. The professional development that they develop and teach is then shared at a follow up session (usually in late November) back at the UNR campus for an intensive one day follow up experience.

The total impact of Nevada Operation Chemistry (1997- 2000) to the State's teachers at well over 800 hours of instruction by our graduates (of the Operation chemistry program) to other teachers (teachers training teachers model) in inservice training and workshops impacting over 1600 people in over 53 different school settings in Nevada. Nevada Operation Chemistry workshops outside of Nevada have now impacted 12 other states, and over 1000 people. These numbers do not include the numerous hours of science teaching that takes place on a daily basis in each one of these teachers' classrooms

Primary instructors for the workshop involve college instructors (Education, Chemistry, Medical School, Biology), District Science Coordinator, industry scientists, classroom teachers, and graduates of the previous years' Nevada Operation Chemistry programs.

Based upon exit interviews and follow-up workshop discussions and presentations with participants from the past three years, Nevada Op Chem has been effective in changing pre-service and practicing teachers' abilities, attitudes and overall confidence in the teaching and learning of chemistry and general science in their classrooms. Science is being taught more frequently in the classrooms of our participants, thus resulting in better science test scores on exams and better grades in science. Two schools with concentrated teachers involved with the program have shown improved scores on standardized test scores school wide. Finally, the participants of Nevada Operation Chemistry are becoming more aware of environmental and industrial concerns and contributions in the state of Nevada.

Nevada Operation Physical Science (NOPS)

Nevada Operation Physical Science is a program designed to enhance the conceptual and activity-related physics/applied physics understandings of K - 8th grade teachers and pre-service teachers throughout Nevada. Specific goals of the program are to a) instill in participants a sense of confidence about their ability to learn and teach basic physics and physical science content in a hands- on inquiry manner; b) make participants competent users of the National Science Education Standards (NSES) and Nevada Science Standards and have participants achieve mastery of physical science (physics related) K-8 standards; c) foster professional growth, including presentation of content and methodology to peers in school, local, state, and national settings; d) make participants aware of the relationship between physics / physical science in the school, university, community, and industry; e) nurture the sense of community and collaboration among participants that is possible with an intensive, long-term program.

Nevada Operation Physical Science has successfully completed two years with 102 participants. The program was very successful in conveying content and pedagogy in the teaching and learning of physical science. Participants included pre-service teachers, elementary teachers, middle level math and science teachers, and a few high school teachers from all across the state of Nevada.

Nevada Operation Physical Science is a cooperative effort between the University of Nevada, Reno, College of Education, College of Engineering and the Mobile Engineering Lab (ME2L), Physics Dept., Chemistry Dept., Nevada State Department of Education (Science), Clark County School District, Douglas County School District, Humboldt County School District, Lyon County School District, Washoe County School District, The Northwest Regional Professional Development Program (Washoe, Pershing, and Storey counties), and the Reno Hilton. Nevada Operation Physical Science is an applied physics workshop covering content in mainly physics - but also covers the content in K-8 physical science standards not covered by Nevada Operation Chemistry I or II.

Nevada Operation Physical Science topics include: force and motion, energy and matter, light, sound, gravity, machines, electricity, magnets, space, and activities relating to the Mobile Engineering Lab (Solar Energy & Force and Motion) which can be brought to individual schools. This workshop was three weekends long beginning late spring. It ran from 12:00 noon to 8:00 PM on Fridays and 8:00 a.m. to 4:00 p.m. on Saturdays for three weekends.

Nevada Operation Physical Science follows the Standards Based, Hands-on Inquiry Model of instruction that is advocated by the National and State Science Education Standards. Additionally, as teachers complete the course, they will become trainers / instructors of other teachers and NOPS in following years.

Research Question

The duration of times of the workshop, Nevada Operation Chemistry (two weeks intensive summer workshop with a Fall follow up) and Nevada Operation Physical Science (three weekend sessions; one a month for three summer months) showed no significant differences on classroom teachers efficacy, and outcome expectancy, as demonstrated on the *Science Teaching Efficacy Belief Instrument* for in-service teachers (STEBI-A) (Riggs & Enochs, 1990).

Methodology

This study utilized a quantitative methodology. The employed design was a modified pretest-posttest design (Campbell & Stanley, 1963). The *Science Teaching Efficacy Belief Instrument* for in-service teachers (STEBI-A) (Riggs & Enochs, 1990) which was originally designed by Riggs (1988), to assess inservice teachers on two sub-scales: personal science teaching efficacy (PSTE) and science teaching outcome expectancy (OE).

The STEBI-A was administered on the first and last day of the two week intensive workshop for Nevada Operation Chemistry and then again four months later at the follow up workshop for Nevada Operation Chemistry. Again, the same instrument was administered on the first day of the first weekend sessions for the NOPS workshop and then on the last weekend of the NOPS workshop (approximately two months later).

The subjects included 47 practicing teachers from the 1999 Nevada Operation Chemistry program and 37 practicing teachers from the 2001 Nevada operation Physical Science program.

All participants are K-8 teachers from Nevada public school districts. Each of the workshops had non practicing teachers and pre-service teachers as additional participants in the workshops, but were not included in this study.

Results

Results of the Analysis of Variance (ANOVA) procedure on the Nevada Operation Chemistry STEBI-A PSTE scores, pre-post, were not found to be statistically significantly different. Outcome expectancy scores were significantly different and can be found in Table 1.

Table 1

Analysis of Variance of Nevada Operation Chemistry Outcome Expectancy Scores, 1999

Source	DF	Sum-Squares	Mean Square	F-Ratio	Prob>F
Between Groups	2	278.4816	139.2408	5.06	0.0083
Within Groups	90	2475.648	27.5072		
TOTAL(Adj)	92	2754.129			

(Groups: Pre-workshop, post-workshop, follow-up workshop)

Due to the significant results of the ANOVA, a Scheffe' Multiple Comparisons Test was performed upon the groups. Results of this procedure can be found in Table 2.

Table 2

Differences Between Pre-Post-Post STEBI-A Outcome Expectancy Scores in Nevada Operation Chemistry, 1999

Groups (A,B,C)	Mean	ABC
Pre-workshop (A)	42.02	. . S
Post-workshop (B)	44.63	. . .
Post-workshop (4 months later) (C)	46.28	S . .

Note: An "S" signifies a statistical difference at the .05 level.

Results of an ANOVA on the 2001 Nevada Operation Physical Science STEBI-A PSTE scores, pre-post, were also not found to be statistically significantly different, just as Nevada Operation Chemistry (see Table 3). Outcome expectancy scores, however, were found to be significantly different, albeit negative, and can be found in Table 4.

Table 3

Descriptive Statistics of Nevada Operation Physical Science PSTE and OE Scores, 2001

Variable	N	Mean	Median	St. Dev	SE Mean
PSTEpre	39	47.974	50.000	5.797	0.928
PSTEpost	37	46.35	46.00	6.33	1.04
OEpre	39	44.436	44.000	4.728	0.757
OEpost	37	42.919	42.000	4.734	0.778

Table 4

Mann-Whitney U Tests on Nevada Operation Physical Science OE scores, 2001

Group	N	Media
Oepre	39	44.000
Oepost	37	42.000

Point estimate for ETA1-ETA2 is -2.000

95.0 Percent CI for ETA1-ETA2 is (-4.000,-0.002)

Test of ETA = ETA Vs ETA not = ETA is significant at 0.0199

The test is significant at 0.0193 (adjusted for ties)

Discussion

This study revealed no difference in teacher efficacy in an intensive two week workshop with a follow up 4 months later as compared to a three weekend workshop over a three month period of time. There were some differences in outcome expectancy in both programs. The Nevada Operation Physical Science (three weekend course) had a drop in outcome expectancy over the time period of the workshop. This result seems to be compatible with other STAB research on professional development that does not include time for teachers to utilize activities in their classrooms. Although there was not a significant difference in outcome expectancy for the Nevada Operation Chemistry intensive two week workshop, there was a significant change in outcome expectancy after the follow up meeting four months later. This positive outcome expectancy change difference is maintained by the fact that the teachers had time to go back to their classrooms and practice the things which they learned during the intensive two week workshop along with working with peers to maintain this change.

Implications for this study include the notion that teachers do need intensive training in both content and pedagogy. However, to establish professional development that makes a difference in the classroom and in practice, more than the intensive workshop is needed. The difference in the Nevada Operation Chemistry group was that the teachers participated as a group from their schools. This lead to continued support throughout the school year as they had peers to work with and try out new ideas. The follow up workshop provided the motivation for the teachers to actually try out different labs and teaching practices so that they would have something to report to the rest of the group. As compared to the NOPS workshop which was three weekends during the summer (one per month for three months), most teachers taught on a traditional schedule and did not have the opportunity to try out activities and teaching approaches with their classes and no follow up requirement was included. Further analysis on extended outcome expectancy should be done for the NOPS group.

This all comes back to the question of what good professional development must include. The results of this study corroborate the findings of the U.S. Department of Education (2000) Longitudinal study and the suggestions from Gess-Newsome (in Rhoton & Bowers, 2001) in her literature review of good components of professional development that show specific things must be incorporated to have a successful professional development program. Amongst those recommendations are the duration of the course (with follow up), sustained support, collective participation and collaboration (with groups from the same schools for support), connections to classroom practices, utilizes content and pedagogy, promotes small changes over time, and involves active learning in all aspects of the professional development.

Further research must be done and shared with productive professional development models in science education. This study has shown that very little difference is made in two intensive weeks or three weekends, both of which are very popular models of professional development. A much more sustained and intensive program model is needed to demonstrate change in teacher efficacy and outcome expectancy is needed.

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