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ABSTRACT

The purpose of this study was to identify whether the strategy of using hands-on science process skills training in an elementary science methods course was effective in: (1) reducing preservice elementary teachers' (PETs') anxiety about teaching hands-on science activities, and (2) changing PETs' concerns about teaching hands-on science activities from concerns about "self" to concerns about "task" and the "impact" of hands-on science on children. A nonequivalent control group quasi-expermental design was utilized. One independent variable, the method of hands-on science process skills training, was investigated. Two measurement instruments (Stages of Concern Questionnaire and State-Trait Anxiety Inventory)--translated into Chinese--were used to measure the dependent variables. The sample consisted of 105 PETs enrolled in 4 sections of a science methods course at Taiwan Provincial Taichung Teachers' College, Republic of China. The experimental group (n=54) received training in hands-on science activities for a period of 6 weeks, while the control group (n=51) received regular class lectures without hands-on science activities. Analysis of covariance (ANCOVA) results indicated that hands-on science process training was significant (P .05) in reducing PETs' anxiety about teaching hands-on science activities and significant (P .05) in changing PETs' concerns about teaching hands-on science activities. However, further descriptive analysis of the data indicated that PETs' concerns about "self" failed to show a decrease; concerns about the "impact" of an innovation showed a slight increasing pattern in the experimental group. (Author/AA)

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The influence of hands-on science process skills training on preservice elementary teachers' anxiety and concerns about teaching science activities in Taiwan, Republic of China

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Abstract

The purpose of this study was to identify whether the strategy of using hands-on science process skills training in an elementary science methods course was effective in: (1) reducing preservice elementary teachers' anxiety about teaching hands-on science activities, and (2) changing preservice elementary teachers' concerns about teaching hands-on science activities from concerns about "self" to concerns about "task" and the "impact" of hands-on science on children.

A nonequivalent control group quasi-experimental design was utilized in this study. One independent variable, the method of hands-on science process skills training, was investigated in this study. There were two dependent variables measured in this study: (1) the state-anxiety about teaching hands-on science activities to children, and (2) the stages of concern profiles about teaching hands-on science activities to children. Two measurement instruments [Stages of Concern Questionnaire (SoCQ) and State-Trait Anxiety Inventory (STAI) Form Y-1] were used in this study. The two instruments used in this study were translated into Chinese by the researcher.

The sample under study consisted of 105 preservice elementary teachers enrolled in four sections of a science methods course at Taiwan Provincial Taichung Teachers' College, Republic of China. The experimental group (n=54) received training in hands-on science activities for a period of 6 weeks, while the control group (n=51) received regular class lectures without hands-on science activities.

Analysis of covariance (ANCOVA) results indicated that hands-on science process training was significant ($P<.05$) in reducing preservice elementary teachers' anxiety about teaching hands-on science activities and significant ($P<.05$) in changing preservice elementary teachers' concerns about teaching hands-on science activities. However, further descriptive analysis of the data indicated that preservice elementary teachers' concerns about "self" failed to show a decrease; concerns about the "impact" of an innovation showed a slight increasing pattern in the experimental group.

The influence of hands-on science process skills training on preservice elementary teachers' anxiety and concerns about teaching science activities in Taiwan, Republic of China.

Significance of the Study

The use of science inquiry methods has been a major objective of science education at all levels since the early 1960s. Reports of several research projects using meta-analysis as well as experimental research studies have convincingly demonstrated that hands-on science programs significantly improve elementary students' science achievement, science process skills' development, and attitudes toward science (Bredderman, 1983, 1985; Shymansky, Hedges, & Woodworth, 1990; Shymansky, Kyle, & Alport, 1982, 1983).

However, there is evidence indicating that a hands-on approach is not widely used for teaching science in elementary schools (Weiss, 1987). Many elementary science teachers feel they are not adequately prepared to teach science. How teachers get trained in their profession affects both their teaching practices and their attitudes. If more science teachers were adequately trained in inquiry-methods used in elementary science programs as part of their preservice science education, the quality of science instruction would increase dramatically (Bethel, 1985).

Presently, the next generation of elementary school science programs are being developed with funding from the National Science Foundation.

The new generation science curricula still emphasize a hands-on inquiry approach (Bybee, 1988; Bybee & Landes, 1988). In order for elementary science programs that stress inquiry to succeed, elementary teachers need to be proficient in teaching science process skills and need to involve children in hands-on science experiences to do this. There is an important need therefore to train preservice elementary teachers to use hands-on inquiry methods in science methods courses to achieve this goal.

Very few elementary teachers describe themselves as well qualified to teach science (Tilgner, 1990). According to Barufaldi's research findings, anxiety may play an important role in elementary teachers' avoidance behavior in teaching science (Barufaldi, 1982). Blosser (1990) in her report "Current Trends and Issues in the Preparation of Teachers of Science" emphasized that science educators need to alleviate science anxiety in elementary teachers and make them feel more confident of their ability to help children learn science.

The incorporation of hands-on science training into elementary science methods courses affects the feelings and/or concerns of the targeted preservice elementary teachers. One way to document user's concerns with an innovation is through the diagnostic instrument, Stages of Concern (SoC) about the innovation (Hall, George, & Rutherford, 1979).

The science instruction at all levels in Taiwan is mostly lecture-oriented (Lee, 1988). Preservice elementary science methods courses in Taiwan are most often taught in a lecture format without hands-on inquiry-oriented science activities being included. Science instructors in Teachers'

Colleges should provide preservice elementary teachers with more hands-on inquiry-oriented learning experiences so that they may develop the prerequisite teaching skills and attitudes necessary for their future science teaching.

Purpose of the Study

The purpose of this study was to identify whether hands-on science process skills training in an elementary science methods course was effective in (1) reducing preservice teachers' anxiety about teaching hands-on science activities, and (2) changing preservice teachers' concerns about teaching hands-on science activities from concerns about "self" to concerns about "task" and the "impact" of hands-on science on children.

Design and Procedures

A nonequivalent control group quasi-experimental design (Borg & Gall, 1983) was utilized in this study. Subjects were 105 preservice elementary teachers (male-52, female-53) enrolled in four classes of a science methods course during the Spring Semester, 1990 at Taiwan Provincial Taichung Teachers' College in Taiwan, Republic of China. The four intact classes were randomly assigned to one of the two experimental groups and two control groups.

The independent variable, the method of science process skills training, was investigated in this study. The treatment consisted of ten science process skills activities (Yu, 1991) given over a six week period (approximately one hour per activity, two activities per week). Two classes of preservice elementary teachers were provided hands-on (manipulative) science process skills training while the remaining two classes of preservice elementary teachers were provided only lecture and discussion with no hands-on science process skills training. The ten hands-on activities included different science process skills (e.g., observing, inferring, predicting, hypothesizing, etc.).

There were two dependent variables measured in this study: (1) the state-anxiety about teaching hands-on science activities to children, and (2) the stages of concern profiles about teaching hands-on science activities to children. Two measurement instruments were used in this study. The first one, the Stages of Concern Questionnaire (SoCQ), is a standardized assessment instrument which was used to measure the subjects' stages of concern (Hall et al., 1979). The second one, the State-Trait Anxiety Inventory (STAI) Form Y-1, is a standardized test which was used to measure the subjects' state anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The two instruments used in this study were translated into Chinese by the researcher (Yu, 1991) and were cross checked by the researcher's Chinese Colleague. The reliability of the Chinese version instruments (i.e., .84 and .95 respectively) were similar to the American versions. Both instruments were administered at the beginning and at the end of the treatment.

All data collected were analyzed using the SAS (Statistical Analysis Systems) statistical package. Analysis of covariance (ANCOVA) was used in order to adjust for the initial differences in pretest scores.

Findings and Discussion

Teacher Anxiety

In comparing the mean pretest and posttest anxiety scores, there was a significant reduction in state-anxiety about teaching hands-on science activities to children (see Table 1). The ANCOVA results indicated that hands-on science process skills training was effective in reducing preservice elementary teachers' state-anxiety about teaching hands-on science activities to children (see Table 2). Preservice elementary teachers who participated in the hands-on science process skills training were less anxious in teaching hands-on science than were preservice elementary teachers who participated in only a lecture and discussion science methods course.

Table 1 Descriptive Statistics of STAI Scores

GROUP	TEST	N	MEAN	SD
Control	Pre-	51	47.33	10.99
	Post-	51	43.94	11.15
Experimental	Pre-	54	48.37	9.97
	Post-	54	39.52	8.39

Table 2 ANCOVA Summary Table for the Posttest Scores on the STAI

Source	Type III SS	df	MS	F	P
Pretest	5006.23	1	5006.23	103.20	0.0001
Adj. Groups	683.83	1	683.83	14.10	0.0003
Error	4948.07	102	48.51		

The results appear to be consistent with the findings derived from past research (Dr. J. P. Barufaldi, personal communication, November 16, 1990; Barufaldi, 1982; Goldsmith, 1987; O'Non, 1988; Westerback, 1982, 1984; Westerback et al., 1985). By reducing their state-anxiety about teaching hands-on science activities to children, preservice teachers feel more comfortable in being required to teach hands-on science activities as the new Taiwan elementary school curriculum requires.

Teacher Concerns

In analyzing data collected on SoCQ, following are the results. The mean pretest and posttest stages of concerns scores are shown in Table 3. The MANCOVA command was used to detect the overall group effect on the seven stages of concern variables. The F value 2.69 of the MANCOVA shows a significant difference ($P<.0137$) between groups for the overall seven stages. The ANCOVA results indicated that there were significant differences in the stage 0 (Awareness, $F=9.16$, $P<.0031$), stage 1 (Informational, $F=16.42$, $P<.0001$), stage 2 (Personal, $F=5.09$, $P<.0262$) (= "self") concerns, stage 4 (Consequence, $F=18.73$, $P<.0001$), stage 5 (Collaboration, $F=6.69$, $P<.0111$), and stage 6 (Refocusing, $F=13.37$, $P<.0004$) (= "impact") concerns about teaching children hands-on science activities after participating in an elementary science methods course by the experimental group when compared to the control group as measured by the SoCQ. However, there was no significant difference at stage 3 (Management, $F=1.76$, $P<.1873$) (= "task") concerns between the groups (see Table 4 - 10).

Table 3 Descriptive Statistics of SoC Pretest and Posttest Scores

GROUP	STAGE	N	M(Pre-)	SD(Pre-)	M(Post-)	SD(Post-)
Control	0	51	9.57	4.43	12 24	5.60
	1	51	29.51	3.98	26.27	5.46
	2	51	27.16	3.56	25.10	4.78
	3	51	21.76	6.49	21.86	5.94
	4	51	30.04	2.97	27.61	5.33
	5	51	28.22	4.09	25.57	5.36
	6	51	24.98	3.13	23.39	4.21
Experimental	0	54	9.91	5.37	9.35	5.64
	1	54	29.37	4.14	29.52	3.79
	2	54	26.63	5.35	26.74	4.90
	3	54	23.96	5.84	21.72	6.11
	4	54	30.20	3.95	30.94	3.30
	5	54	28.31	4.72	27.78	4.49
	6	54	25.11	4.36	26.02	3.74

Table 4 ANCOVA Summary Table for the Stage 0 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	552.57	1	552.57	20.87	0.0001
Adj. Groups	242.48	1	242.48	9.16	0.0031
Error	2700.92	102	26.48		

Table 5 ANCOVA Summary Table for the Stage 1 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	459.87	1	459.87	26.18	0.0001
Adj. Groups	288.42	1	288.42	16.42	0.0001
Error	1791.77	102	17.57		

Table 6 ANCOVA Summary Table for the Stage 2 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	521.32	1	521.32	28.05	0.0001
Adj. Groups	94.59	1	94.59	5.09	0.0262
Error	1895.56	102	18.58		

Table 7 ANCOVA Summary Table for the Stage 3 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	1145.58	1	1145.58	44.95	0.0001
Adj. Groups	44.92	1	44.92	1.76	0.1873
Error	2599.29	102	25.48		

Table 8 ANCOVA Summary Table for the Stage 4 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	507.49	1	507.49	34.71	0.0001
Adj. Groups	273.92	1	273.92	18.73	0.0001
Error	1491.50	102	14.62		

Table 9 ANCOVA Summary Table for the Stage 5 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	650.82	1	650.82	35.82	0.0001
Adj. Groups	121.55	1	121.55	6.69	0.0111
Error	1853.03	102	18.17		

Table 10 ANCOVA Summary Table for the Stage 6 Posttest Scores on the SoCQ

Source	Type III SS	df	MS	F	P
Pretest	313.84	1	313.84	24.30	0.0001
Adj. Groups	172.71	1	172.71	13.37	0.0004
Error	1317.29	102	12.91		

While there were significant differences between the groups in six out of seven stages of concerns from the ANCOVA analysis, little information is provided as to the nature of the stages of concerns profiles and whether or not individual stages are more or less intense. The percentile rank profile analysis was used for further analysis. The results indicated that there was an increase of scores in both stage 4 (Consequence), and stage 6 (Refocusing) in the experimental group. However, the scores did not decrease for the experimental group in stage 1 (Informational), and stage 2 (Personal) concerns (see Table 11 & Figure 1). Thus while there appeared to be a slight increase in intensity for stages 4 and 6 concerns about teaching hands-on science activities to children by the experimental group, scores at the lower levels (i.e., "self") remained almost constant for them. Self concerns remained constant even after the treatment.

The small reduction in the stage 0 concern in the experimental group indicates that the hands-on science process skills training was somewhat effective. The increase in intensity of the stage 4 concern and together with no change in the stage 5 concern of the experimental group suggests that preservice elementary teachers will probably work individually to impact student gains in science. This is again consistent with Concerns Based Adoption Model (CBAM) theory because teachers tend to work individually in implementing a new innovation. After working with the innovation for some time they tend to move toward collaborating in order to maximize their impact on children's success in science. The increase in intensity of the stage 6 concern in the experimental group suggests that these preservice

Table 11 SoC Mean Percentile Ranks (U. S. A. / Chinese norm)

Group	SoC STAGES						
	0	1	2	3	4	5	6
Control							
Pretest (U.S.A.)	81	97	89	83	76	80	84
Posttest (U.S.A.)	86	91	85	83	66	72	77
Change within	+5	-6	-4	0	-10*	-8	-7
Experiment							
Pretest (U.S.A.)	81	96	89	88	76	80	84
Posttest (U.S.A.)	77	97	89	83	82	80	87
Change within	-4	+1	0	-5	+6	0	+3
Between Group Change (U.S.A.)	9	7	4	5	16*	8	10*
Control							
Pretest (Ch)	51	72	52	49	52	49	54
Posttest (Ch)	68	38	39	49	36	35	35
Change within	+17	-34	-13	0	-16	-14	-19
Experiment							
Pretest (Ch)	51	66	52	61	52	49	54
Posttest (Ch)	46	72	52	49	63	49	64
Change within	-5	+6	0	-12	+11	0	+10
Between Group Change (Ch)	22	40	13	12	27	14	29

Note. * A 10 percentile change in the U. S. A. norm was considered significant by the developer of the SoC.

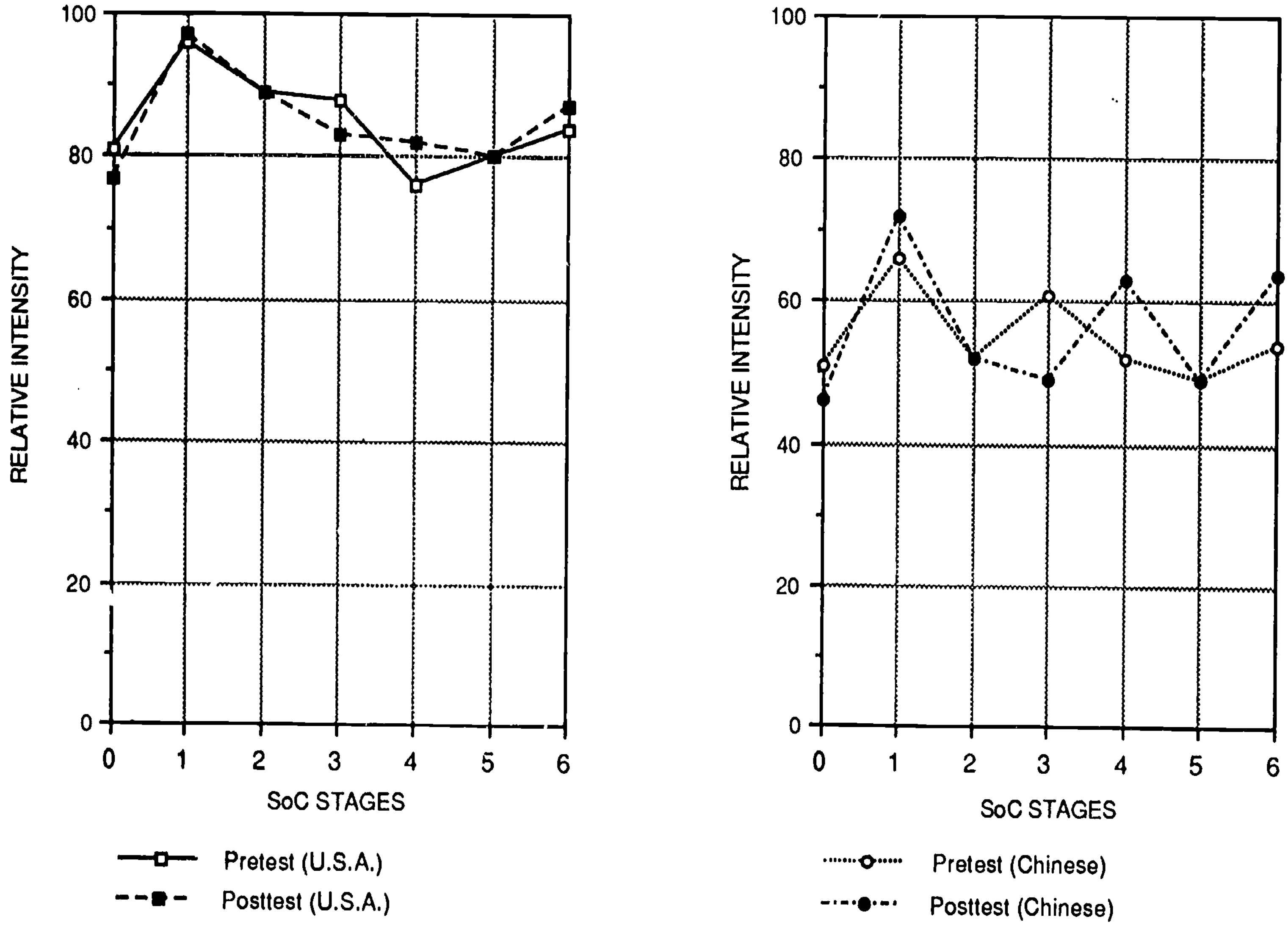

Figure 1 Experimental Group Mean Pre- and Posttest Scores on the SoCQ

teachers may have had some other ideas about additional methods for improving their hands-on science teaching. However, they are still nonusers at this stage of their careers and this should be kept in mind when analyzing the profiles, particularly in the later stages of concerns.

Several concerns profiles in this study did not conform to current CBAM theory. For example, no decrease in the lower stages of concerns (e.g., stage 1 & 2) occurred in the experimental group. Reasons for these findings which are not consistent with the CBAM theory may possibly be attributed to one or more of the following:

1) Change is a process requiring developmental growth and learning. Change takes time. The time required for change depends on the complexity of the nature of the innovation being implemented. Because of the relatively short duration (two hours per week for six weeks) of this treatment, a large change would not be expected. The SoCQ may not have been sensitive enough to detect subtle changes of concerns in this study over a short period of time.

2) The experimental group in this study was high on stage 0, stage 1 and stage 2 both before and after the treatment. This probably means that they were nonusers of the innovation teaching hands-on science activities to children. They also had very intense concerns about the innovation and wanted more information. During the treatment period, they were not teaching hands-on science activities to children at all, but they were doing hands-on science activities. Therefore, their "self" concerns did not change

during the period between the pretest and the posttest. Again more experiences and information were required by the experimental group.

3) The experimental group might have felt that they needed more information on hands-on science teaching when they actually manipulated the materials (Dr. W. L. Rutherford, personal communication, May, 1990). Therefore, their "self" concerns did not change from pretest to posttest.

4) The instrument (SoCQ) was designed for inservice teachers. Much research conducted in recent years has been with inservice teachers (Barufaldi, 1982; Barufaldi et al., 1990; Bethel & Hord, 1981, 1982; Zielinski, 1986). The concerns of preservice teachers are somewhat different from those of inservice teachers. Most of the items on the Stages of Concerns Questionnaire are far more relevant and appropriate to the concerns of inservice teachers as oppose to preservice teachers. For example:

- I would like to know the effect of reorganization on my professional status. (item 7, Stage 2/Personal)
- I would like to know how my teaching or administration is supposed to change. (item 17, Stage 2/Personal)

These two items belong to stage 2, "self" concerns (Malone, 1984). Many of the items designed for inservice teachers may seem vague when preservice teachers try to apply them to their current student teaching situation (O'Sullivan & Zielinski, 1989). O'Sullivan & Zielinski (1989) were trying to make some minor modification on this instrument in order to use it with preservice teachers on a regular basis during their student teaching experience. Results on the proposed changes have not yet been published.

5) The Chinese norms were chosen for converting raw scores into percentile ranks because this norm was established from the translated Chinese version of the SoCQ using a sample of Chinese preservice elementary teachers. Although the Chinese norm may be more appropriate for use in this study than the American norm, the sample size for establishing the norm may not have been large enough to obtain a more stable and standardized norm. Also, there were bigger variations in the Chinese norms than the American norms.

In summary, the final results of the study reveal that "self" concerns are very important to members of both groups when confronted with the possible implementation of an innovation--namely a process approach to teaching science to elementary children. They must be made aware of the innovation and then provided with information together with some meaningful form of experience with it. Once these concerns have been met, then teachers are able to begin to seriously implement and work with the new science activity program. What has been seen here is that even a mild intervention such as the hands-on science process skills training has had a significant impact on both the experimental groups' state-anxiety and concerns profiles when compared to the control group. Thus it would seem that future elementary science methods courses include some kind of hands-on process-oriented instruction in order to begin to ensure some kind of significant implementation of the new Taiwan elementary science program which has now been mandated for several years. Barriers to teachers using hands-on science activities would begin to disappear and the quality of science instruction would be initiated in a more permanent manner. The quality of scientific literacy would be enhanced. Many of the ideas suggested here would also have value in a state-wide continuing education or inservice program designed to up-grade the quality of science instruction at the elementary levels.

To develop teaching behaviors that actually promote learning through inquiry, preservice teachers must do more than just study or talk about inquiry. Teaching behaviors will change if students actually practice teaching science skills that promote inquiry, receive feedback and then teach again. Science education programs must provide opportunities through which prospective teachers can have such meaningful inquiry experiences. Subsequently, these teachers contemplate the nature of student inquiry behaviors such as observing, interpreting data, predicting, testing predictions, explaining, questioning, and applying. At the same time, they apply these processes to their own understanding of the teaching of science. Finally, they try to provide inquiry experiences for their own students in actual classroom settings.

Conclusions and Implications

Conclusions

It can be concluded that preservice elementary teachers in a Taiwan teachers' college are anxious about teaching hands-on science activities to children before participating in hands-on science process skills training or taking any elementary science methods course. This is not surprising because they have had little exposure to hands-on science experiences.

Hands-on science process skills training does reduce their anxiety about teaching hands-on science activities to children. Therefore, more hands-on science activities included in elementary science methods courses would be very useful in helping preservice elementary teachers to overcome this serious barrier.

Preservice elementary teachers in Taiwan, R. O. C. are highly concerned about "self" concerns when asked to teach hands-on science activities to children before enrolling in an elementary science methods course. They know very little about teaching hands-on science activities to children prior to participating in this study based on the current educational practices in the Taiwan schools.

Hands-on science process skills training changes their stages of concerns profile about teaching hands-on science activities by increasing the higher stages (4, and 6 "impact" concerns) of the concerns profile. However, the training did not decrease the lower stages (1, and 2 "self" concerns) of the concerns profile about teaching hands-on science activities. This is reasonable given the amount of time needed to feel comfortable about an innovation. As they become more familiar with the method through teaching, their "self" concerns will begin to diminish and management and impact concerns will become more intense.

Implications

Hands-on science process skills training may be integrated into elementary science methods courses in teachers' college in Taiwan, R. O. C. in order to reduce preservice elementary teachers' anxiety about teaching hands-on science activities and to improve their stages of concerns from concerns about "self" to concerns about "task" and toward "impact" of hands-on science with little difficulty. No problems were encountered in the inclusion of the activities during the study.

Curriculum developers or instructors of elementary science methods courses in Taiwan, R. O. C. may want to consider designing hands-on science activities for inclusion in the college curriculum for training preservice elementary science teachers.

Hands-on science process skills training is not only used for preservice elementary teachers but may also be used for inservice training of elementary science teachers in Taiwan in order to reduce their avoidance of teaching hands-on science activities to children and to improve their concerns from "self" to concerns about "task" and toward the "impact" of hands-on science on their children's intellectual development. It can be seen that the SoCQ can be a valuable instrument for use in designing preservice programs for training future elementary school teachers as well as used for inservice teacher training.

Limitations

Because the population to be studied consists of preservice elementary teachers in Taiwan, Republic of China, the findings can be generalized only to this population of teachers. However, this does not negate the fact that hands-on science experiences do have a positive effect on teachers.

Because of time constraints the investigator did not have the data available for test-retest reliability. O'Sullivan & Zielinski (1989) found low level test-retest reliability of the modified SoCQ in their study and raised a serious question about the reliability of the instrument (SoCQ). However, they were working with an altered version of this instrument. There is no reason to assume however that this is the case in this study. More needs to be done here.

Limited availability of subjects that could be used to establish the reliability and validity of the complicated instrument (SoCQ) caused the following: 1) The internal reliability of the various concerns levels of the Chinese version SoCQ were lower than the American version; and 2) Small sample size prevented the investigator from doing a factor analysis of the SoCQ.

Recommendations for Further Research

The Chinese version of the SoCQ instrument needs further study and possibly some changes. It needs to be refined specifically for preservice elementary teachers in Taiwan, R. O. C. by a group of researchers. A larger sample size is needed in order to establish the reliability, validity, and standard norm of the instrument. It is through this process that a valuable instrument required for the implementation of innovations can be developed for use in Taiwan and other countries.

An attempt should be made to replicate this study. But some modifications should be made. While the experimental design is adequate, more time for the treatment should be allowed together with the inclusion of additional process-oriented science activities. Specific attention should be given to the use of the Stages of Concern Questionnaire (SoCQ) and its use in the implementation of innovations. More time should be given to a study of this nature. Perhaps including science activities for an entire semester (about 15 weeks) might prove to be more effective. But keep in mind that change is a process and it requires time for it to take place within the classroom, within the school, and even within the educational system.

Perhaps elementary children can be brought into the teachers' college for the purpose of allowing preservice elementary teachers opportunities to teach them science through hands-on activities. This would help to approximate the actual school conditions in which they will be required to teach science activities to elementary children.

A follow-up survey of the subjects who participated in this study during their student teaching and first year of formal teaching would be valuable. Again anxiety and level of concerns can be measured in order to ascertain the impact of the hands-on science process activities experienced in an elementary science methods class. This procedure would also determine the long term effects of the treatment on subjects' willingness to teach hands-on science activities.

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