DOCUMENT RESUME

ED 406 149 SE 059 807

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TITLE	Science Experiences and Attitudes of Elementary Education Majors as They Experience Biology 295: A Multiple Case Study and Substantive Theory.
PUB DATE	Mar 97
NOTE	22p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (70th, Oak Brook, IL, March, 1997).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Anxiety; *Biology; Case Studies; *Course Content; Curriculum Development; *Education Majors; Elementary Education; Higher Education; *Preservice Teacher Education; Professional Development; Program Evaluation; Science Curriculum; *Teacher Attitudes; *Teacher Education Programs; Teaching Methods; Training Methods

ABSTRACT

In response to national reform movements, an introductory biology content science course specifically designed for elementary education majors has been developed and implemented for 3 years in a collaborative manner between the School of Biological Sciences and the Teachers College. Preliminary and ongoing quantitative survey analysis of teacher attitudes towards science showed statistical significance in all sections taught and analyzed over the past 3 years. This is an in-depth qualitative multiple-case study using cross-case analysis to explore the reasons for the attitude and confidence shift, and to generate a substantive theory based upon the findings. Evidence collected and analyzed came from journal entries, pre- and post-interviews, videotape, informal conversations, classroom assignments, and teaching assignments. Data clearly showed similar themes in each case. Cross-case analyses showed a personal progression in learning content biology with a concurrent philosophical development. This cross-case comparison led to a substantive theory of how preservice teachers experience learning in this alternative-content science course. The substantive theory clearly labeled hurdles which each of the participants experienced and overcame with participation in the course. Contains 63 references. (Author/PVD)

Science Experiences and Attitudes of Elementary Education Majors as they Experience Biology 295: A Multiple Case Study and Substantive Theory

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Paper presented at the International Conference of the National Association for Research in Science Teaching. (NARST)
Chicago, Illinois. March 1997

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Science Experiences & Attitudes of Elementary Education Majors As They Experience Biology 295: A Multiple Case Study & Substantive Theory

Abstract

In response to national reform movements an introductory biology content science course specifically designed for elementary education majors has been developed and implemented for three years in a collaborative manner between the School of Biological Sciences and the Teachers College.

Preliminary and ongoing quantitative survey analysis of teacher attitudes towards science showed statistical significance in all sections taught and analyzed over the past three years. Statistically significant differences were also found on the National Association of Biology Teachers (NABT) Content Biology Exam and the Science Teaching Efficacy Belief Instrument (STEBI B) for preservice teachers (Enochs & Riggs, 1990).

This study is an in-depth qualitative multiple case study using cross case analysis to explore the reasons of the attitude and confidence shift and to generate a substantive theory based upon the findings. Evidence collected and analyzed came from journal entries, pre and post interviews, video tape, informal conversations, classroom assignments, and teaching assignments. The data clearly show themes similar in each case. Cross case analyses show a personal progression in learning content biology with a concurrent philosophical development. This cross case comparison lead to a substantive theory of how preservice teachers experience learning in this alternative content science course. The substantive theory clearly labeled hurdles which each of the participants experienced and overcame with participation in the course.

Foreword

A reflection in the snow

It is five o'clock pm. With a bag of greasy fast food from the student Union I am once again rushing to the science building to teach my biology class. At this time of year the sun has already set and there is a definite chill in the air. Most of the leaves have dropped and I watch them swirl, intermingled with a few snow crystals, in the ever constant wind that we receive in the Midwest throughout the winter. The life sciences building is across campus from the Teachers College, where my office is and where I usually teach. So, as I lug a huge cart across campus with the large quantity of hands-on supplies that are necessary for the introductory level content biology class for elementary education majors, I am once again going over in my mind the order of events for the night. I look up and see other people rushing to unknown places and my thoughts drift to the first time I ever made this trek. I was with two others that bitter cold evening in January. It is funny how so many things have changed in less than one year.

I walk into the biology building and immediately the smell of formaldehyde permeates the air, the white washed walls and quietness seem stereotypical of this setting. I walk past labs where intricate distillation processes are set up, where masses of whirring machines are busy doing there assigned tasks, and people are dressed in white lab coats and never really look at you. I finally reach my classroom, the faculty meeting room, which is the only room in the entire building where the tables are not permanently bolted to the floor. There is an entire bank of windows, a few plants, carpet on the floor, and a stack of folding tables and chairs. I quickly close the door and sigh a breath of relief as I begin to make changes. I set up the tables so that four people can be seated around each of them. There is no real pattern to where the tables are set up, just islands in the room which will catch a group of four students. I set up a portabl e stereo and start playing a compact disc with sounds and music from the rainforest. I unload the rest of the supplies and spread them out on the desks and the counters on the sides of the room. There are enough supplies and equipment for each person in the class to actively participate in each of the evenings activities. The door opens and my teaching partner, Kathy, enters the room - also breathing a sigh of relief, not from the scientific atmosphere - as she teaches science at a high school and is used to the laboratory environment, but rather because she made it safely to town from her weekly 70 mile sojourn to teach the class. Together we finish preparations for the evening.

The first students trickle in and are anxious to get their journals back, we usually respond in writing weekly to the reflections and notes that they keep for class. At exactly 5:30 pm. all of the students (the majority being college sophomores and white females) have arrived and the classroom is bustling with laughter, excitement, and anticipation. Many students also have their dinner with them, along with their "tool boxes" containing colored pens and pencils, scissors, string, glue, markers, and all of the other essentials that an experienced elementary teacher would have in the classroom. We use a cooperative learning hand signal, a hand raised in the air, and the students immediately give the appropriate signal back and the room is quiet - for the moment. We begin each lab by sharing thoughts out of journals and recapping events from previous labs. Most of the students are eager to share thoughts and experiences, knowing that they can do so and no one will think the less of them. We conclude this ritual and immediately begin with the lab for the evening. We are dealing with food chains/webs, and trophic pyramids. The assignment is to create a food web from a chosen ecosystem on a poster using pictures cut out of NebraskaLand magazine depicting the interrelationships of different organisms by connecting them with strings of yarn. The room is noisy and quickly scraps of paper pile up and yarn fragments are all over the floor. When the groups are finished, we share our posters group by group and notice that over two hours of class have gone by.

We then get together as a group and push back all of the tables. Each person has an assigned animal card. We organize ourselves in the shape of a pyramid with the tertiary consumer at the top, second level consumers next, first order consumers follow, with producers at the bottom. We then throw a huge ball of yarn around the room beginning with a producer who holds the string and then throws it to the organism that eats her, she holds the next segment of string, and so on until all of the food chains are inter-linked into a yarn web. We then discuss the human impact on an ecosystem by using a scenario of a new housing development that will be built on this ecosystem. The developer brings in a bulldozer and clears off all of the producers. All of the producers in the room release their hold on the string because they are now dead. The impact of the producers is felt by the first level consumers and they then let go of the string, and so on up the line until every one has either died or has moved to another environment where they can compete for survival. The clock is now at 9:35 and we realize that our four hour lab has once again run over time. We quickly give the journal assignment and excuse the students.

The room is a wreck, we are exhausted, and it is getting late as the last few stragglers leave the room around 10:00 pm. Kathy and I clean up, fold up the tables and cha irs, and repack our stuff. The room is once again quiet and we shut off the lights, close the door, and quickly exit through the sterile halls out into the freshly fallen snow.

We are subtle instruments of change that come and go in the dark cold night.

Problem

Science literacy/preparation for students at all levels of learning has been a topic of great concern in the education community for the past decade (American Association for the Advancement of Science (AAAS), Project 2061, 1989; & AAAS, Benchmarks, 1991). The professional literature clearly notes a lack of science preparation and literacy for elementary teachers being prepared by universities. (NRC, 1996; Fort, 1993; Tobias 1990 & 1992). Researchers suggest that the problem of science literacy, stemming from early years in schooling, is perpetuated in the current structure of the undergraduate introductory level science courses. They propose that negative or passive attitudes are rekindled and solidified and are subsequently passed on to the next generation of learners. The National Research Council's (NRC, 1990) identified problems and needs are explained in *Fulfilling the Promise: Biology Education in the Nation's Schools*. They state that:

> Teachers of science in elementary school must be far better prepared than are most at present. To disguise their anxieties about science, most elementary school science teachers have hidden behind textbook-centered lessons that stress vocabulary and memorization of facts. Given the minimal amount of science instruction taken in college by most elementary -school teachers, that attitude is understandable. But the situation must change to achieve quality science instruction in the elementary schools. . . (p.16).

Preservice elementary teachers' science preparation is described as inadequate, both in content and methodology of instruction (NRC, 1996; NRC, 1990; Tobias 1992). These studies attribute the lack of preparation to: 1) The structure of traditional introductory level content science and methods courses and 2) The prevailing attitude among most elementary education majors that science and math are difficult and uninteresting subjects. This study proposes that both preparation issues are interrelated and that the problem may be addressed by developing collaborative content science courses for preservice teachers between science departments and teacher colleges which integrate the methodologies and pedagogies currently advocated by national reform efforts in conjunction with the teaching and learning of content science.

Purpose

The purpose of this study was to explore science experiences and attitudes in a select group of preservice elementary education majors enrolled in an experimental introductory level content biology course. Qualitative case study methodology was used in order to produce a holistic picture of how a preservice elementary teacher experiences this course. Multiple case comparisons have led to the generation of a substantive theory of the progressional aspects or hurdles that elementary preservice teachers encounter, overcome, and achieve as they learn science in this alternative environment.

Background:

In the fall semester of 1993 a new undergraduate content biology course for elementary education majors was designed; Biological Sciences 295.

Biology 295 (Hands-on Biology for Elementary Education Majors) is a course for elementary education majors designed to teach simultaneously biological concepts and pedagogy through the scientific process. This course is based upon the science literacy standards advocated by the National Research Council in the recently released *National Science Education Standards* (1996 and preceding draft editions), the American Association for Advancement in Science (AAAS) in *Project 2061* (AAAS, 1989), *Benchmarks* (AAAS, 1994), National Science Teachers Association's (NSTA) *Scope, Sequence & Coordination of Secondary School Science:* Vol. I - *Content Core* and Vol II - *Relevant Research* (1992), and Nebraska Department of Education's *Math and Science Frameworks* (1994). Also considered are the goals of the nation and the state as covered in Project 2000.

The philosophy of the course is rooted in constructivism, thus emphasizing individual students' background, culture, philosophies, and needs (Tobin, 1993; Cobern, 1989; Von Glasersfeld, 1989). The curriculum provides students with a knowledge base of biological concepts and integrates pedagogy traditionally taught in separate education classes.

The knowledge base, as explored in the course, allows prospective teachers to do hands-on activities and to use discovery/inquiry types of instructional techniques which require a profound understanding of biological content. The curriculum aims to encourage preservice elementary education majors to integrate biological concepts more substantively into their teaching curriculum.

The curriculum also provides for modes of alternative assessment which require students to demonstrate their ability and knowledge through performance related tasks. The course is designed to empower preservice elementary education majors to become agents of change, so that they in turn may empower their students to guide their own learning through the scientific process.

Since the Spring term 1994 quantitative data have been collected on both content biology and attitude surveys. Content biology was measured by using a pre post test design on the National Association of Biology Teachers (NABT) Biology Content Exam. In a previous study (Bruning & Glider; unpublished), thirty questions had been selected from the NABT exam and administered to general Biology 101 courses at the University of Nebraska Lincoln. The same instrument, constructed of a subset of questions from the NABT exam, was administered each semester to the Biology 295 students. Results from a pre post two tailed t test analysis show significant alpha values ($<.05$) for each semester. Results from the two sections of the Fall semester 1995 are shown inTable 1. Other semesters are not included in the table but had similar significance of $<.001$.

(Insert Table one here)

Table 1: NABT Exam Results.

Section	Pre-Test X	Pre-Test SD	Post-Test X	Post-Test SD	t	p
Fall '95 N = 28	12.32	3.54	16.5	3.24	-6.75	<.001
Fall '95 N = 28	12.61	3.79	17.07	3.75	-7.54	<.001

The Science Attitudes survey (Bruning, unpublished) is a survey which explores five areas related to overall confidence and attitude. Areas examined are: A) Confidence in learning science as a student; B) Utility of science; C) Affect of science; D) Gender and ability to learn science; E) Constructivist learning and teaching in science; F) Confidence in teaching content science in the classroom and; G) Confidence in teaching science and sharing it in professional circles. Using the instrument with corresponding reliability within acceptable ranges this instrument was administered each semester to the Biology 295 students. Results from a pre / post two tailed T-test analysis show significant alpha values for each semester in each category. Table 2 is a comprehensive analysis of all the students. Significant alpha values for each component of the test were found.

(Insert Table 2 here)

Table 2: Science Attitudes Survey Results.

variable N = 115	Pre-test X	Pre-Test SD	Post-test X	Post-test SD	t	p	∝ Pre-test	∝ Post-test
Confid	29.33	7.35	35.78	7.59	-9.96	<.001	.87	.89
Utility	32.59	4.88	36.61	5.12	-7.65	<.001	.72	.76
Affect	28.08	8.55	35.9	7.55	-10.04	<.001	.91	.87
Gender	29.47	6.01	31.35	4.64	-3.88	<.001	.88	.86
Constructivism (*)	11.58	2.66	14.21	10.32	-2.67	<.01	.64	.95
Content a	44.81	10.19	51.16	9.32	-6.44	<.001	.91	.92
Content b	43.52	12.16	52.87	10.77	-7.09	<.001	.88	.93

(* Note that the figures in the constructivist column don't make sense due to an error in the reverse coding of the instrument and the statistical interpretation thereof.)

The preliminary quantitative findings proved encouraging and led to further questions about the course. Many studies conclude with the development, evaluation, significant quantitative findings, and resulting publicity. Making a difference, however, is only the beginning to understanding how and why these significant changes were brought about.

Biology 295 is an unique bounded system and all of the above findings provide a rationale to study the course qualitatively. Specifically, studying the experiences and attitudinal progression of preservice elementary education majors over the duration of the course could provide valuable information which may lead to the development of theories on how alternative science courses help students overcome barriers to learning and teaching science. This also addresses the national concern of science literacy for students on all levels and their respective teachers.

Methodology

Having a quantitative basis to show that a significant event has taken place, qualitative analyses were required to explain the how and why changes occurred as a result of experiencing biology 295. Therefore, the research for this study followed the qualitative paradigm and attempts to explain the significant quantitative findings while concurrently distilling patterns that emerge from the participants experiences thus leading to the generation of a substantive theory of learning science in an alternative setting.

Merriam (1988) defined qualitative research and emphasized the need to explore subjective phenomenon: “(Q)ualitative research assumes that there are multiple realities - that the world is not an objective thing out there but a function of personal interaction and perception. It is a highly subjective phenomenon in need of interpreting rather than measuring” (p.17).

Having multiple data sources, a context or bounded system, and a phenomenon to study led to a case study design. A case study is universally defined as, "(A) detailed examination of one setting, or a single subject, a single depository of documents, or one particular event” (Bogdan & Biklen, 1992, p.62). Merriam (1988) further clarified a case study as "an examination of a specific phenomenon such as a program, an event, a person, a process, an institution, or a social group"(p.9).

Case studies require that the subject or phenomenon being studied qualify as a bounded system. Merriam (1988) explains, "The bounded system, or case, might be selected because it is an instance of some concern, issue or hypothesis" (p.10). Adelman, Jenkins and Kemmis (1983), simplify the explanation by stating, "The most straight forward examples of 'bounded systems' are those in which the boundaries have a common sense obviousness, e.g. an individual teacher, a single school, or perhaps an innovatory programme" (p.3).

Additional exploration of case study designs revealed explanations of multiple case studies. Merriam (1988) explained that "the case study focuses on a single unit within there may be several examples, events, or situations (which) can be exemplified by numerous case studies" (p.46). Yin (1984) proposed that multi case studies try to "build a general explanation that fits each of the individual cases, even though the cases will vary in their details." (p.108). Miles and Huberman (1984) suggested that "by comparing sites or cases, one can establish the range of generality of a finding or explanation, and at the same time, pin down the conditions under which that finding will occur." (p.151).

Further study of Merriam (1988), Bogdan and Biklen (1992), and Denzin and Lincoln (1994), led to the realization that case studies often lend themselves to developing theory. Merriam (1988) explained that, "A qualitative inductive multi case study seeks to build abstractions across cases" (p.154). After clarifying the account of several case studies within the same context or bounded system, Merriam (1988) elaborated, "Anchored in real-life situations, the case study results in a rich and holistic account of the phenomenon. . . . case studies play an important role in advancing a field's knowledge base" (p.32) and that "qualitative case study usually builds theory" (p.57). Stake (1994), suggests that a "Case study can usually be seen as a small step toward grand generalization" (p.238). Finally, Merriam (1988) stated that it is appropriate inductively to discover theory from case study research when there is no theory present which explains the phenomenon. She stated:

> The case study has been widely used, however, in the service of constructing theory. It becomes necessary to build theory when there is none available to explain a particular phenomenon or when existing theory does not provide an adequate or appropriate explanation. Eckestein (1975, p.104) calls theory building case studies "heuristic" because they "aim to find out." Case studies that are undertaken to build theory use an inductive rather than deductive mode of thinking about the problem and analyzing the data. These studies, which have as their goal discovery of theory rather than verification, partake of the qualitative paradigm. . . . (p.59).

The research within case study methodology is consistent in emphasizing purposeful selection when selecting individuals as case studies in a bounded system. Merriam (1988) defined and rationalized at the same time purposeful selection:

> (P)robabalistic sampling is not necessary or even justifiable in qualitative research. Anthropologists, for example, have long maintained that nonprobability sampling methods "are logical . . . ." (Honigmann, 1982, p.84). Thus the most appropriate sampling strategy is nonprobablistic - the common form of which is called purposive (Chein, 1981) or purposeful (Patton, 1980). Purposive sampling is based on the assumption that one wants to discover, understand, gain insight; therefore one needs to select a sample from which one can learn the most (pp. 47-48).

Utilizing the methodology of purposeful selection, six preservice elementary education majors [hereafter referred to as students] were self selected from the Spring 1995 Biology 295 class. The criteria for selection required students with different backgrounds in and understandings of science. Based upon the works of Tobias (1990) and Fort (1993) two students were selected from the First Tier (Tobias) or as Fort suggests, Science Smart. These students possessed a strong science content knowledge and had positive experience with the subject matter. Two students were selected from the Second Tier (Tobias) or as Fort suggests, Science Savvy. These students possessed the ability and confidence to learn science, but had little experience with the content. And, two students were selected from the Third Tier or majority (Tobias) or as Fort suggests, Science Shy. These students possessed ability to learn science, but had attitudes reflecting little or no confidence in learning science as a result of no experience with science or bad experiences previously encountered while learning science.

Using purposeful selection of six participants enabled a multi case study design. Thick and rich descriptions were developed of each participant and their experiences and progression in attitude, confidence and philosophy as they experienced Biology 295. By using cross case analysis to look for common strands and themes, a substantive theory was generated which explores the barriers and hurdles that preservice elementary education majors encounter and overcome in the progression of learning science in this alternative learning environment. This theory was based upon their experiences and attitudes resulting from participation in Biology 295.

The cross case analysis and the generation of the substantive theory were reviewed by an outside reviewer. The outside reviewer read each of the cases and then verified the cross case analysis with accompanying substantive theory as an accurate deduction from the data. Denzin and Lincoln (1994) state that an outside reviewer is an excellent way of keeping the research and theory in the proper context and thereby limiting researcher bias. Therefore, the results, both by individual cases and cross case comparison generate a fair interpretation and theory based upon the attitudes and experiences of these students as they experienced Biology 295.

Nature of the Data

Major data sources for this study included manuscripts from pre and post interviews with each participant, journals that each preservice elementary education major kept as a student involved with the Biology 295 course, and video taped segments of the different class sessions.

The interviews with each of the participants were conducted at the beginning of the course and at the end of the course. The final interview allowed the participants to share any further insight that they had relating to experiences and attitudes as a result of being in the course. The interviews were conducted in such a way that the participants felt comfortable to "talk freely about their points of view" (Bogdan & Biklen, p.97).

Posner (1993) came up with a logical formula by which the journaling assignments were based upon: (E + R = PG) "experience plus reflection equals personal growth." As part of the class stipulations, each student was required to keep a reflective journal of the labs, activities, and events of the course in a two way dialogue format. Topics to reflect upon included specific lab activities and related scientific content, relating content to real life experiences, pedagogical strategies modeled or conveyed in class, classroom connections (projecting the usefulness of the content and course to their future classrooms), and their thoughts and feelings that they discovered as they participated in class. All of these journaling experiences were designed to further the students' understanding and learning as a part of their personal growth. Fulwiler (1980) summarized the importance of written documents as the "text content provides a window of understanding about how effectively people observe events, speculate, revise thinking, and reach conclusions."

During the entire semester each lab was video taped. Approximately sixty hours of video tape were accumulated from labs and corresponding activities. The video taping was conducted as a record of the labs and provided a visual component to the written responses that the participants made in their journals

With the above data sources and participant observation records kept by the researcher, massive amounts of rich descriptive data were obtained. Using the qualitative methodology as described above and following the advice of Bogdan and Biklen (1992) that "As you read through your data, certain words, phrases, patterns of behavior, subjects' ways of thinking, and events repeat and stand out" (p.166), the thick and rich descriptions which were developed with each participant and their experiences led to the themes developed by each individual case.

Further analysis incorporated Miles and Huberman (1994) suggested strategies for cross-case analysis. "A conceptual framework oversees the first case study, then successive cases are examined to see whether the new pattern matches the one found earlier" (p.436). Merriam (1988), suggested, "using an 'unordered meta-matrix' - a large chart organized by variables of interest to the researchers that contains bits of narrative such as key phrases, quotes, or other illustrations of the category . . . by doing this one can advance to higher levels of analysis." (p.155).

The higher levels of analysis led to a substantive theory, "a theory restricted to a particular setting, group, time, population, or problem" (Merriam, 1988. p.57), which was based upon the multiple data sources and cross case comparisons.

Findings and Results: Cross Case Analysis and Substantive Theory

Science education and science instruction in the elementary school has been a topic of research for quite some time. In 1978 Weiss found that only 28% of elementary teachers felt qualified to teach science and that on the average 90 minutes per day were spent on reading instruction versus an average of 17 minutes on science instruction. These results have been corroborated by Stefanich and Kelsey (1989) who found that less time is spent on science instruction in elementary schools than any other subject. Of the time spent on science instruction, an earlier study found that 90% of the teachers relied on textbooks for about 90% of their science instruction (Stake & Easley, 1978). Yager and Lutz (1994) found similar results and further explained that science instruction was comprised of students listening to lectures, reading from textbooks, and memorizing, repeating and confirming scientific facts. More importantly, a study done by Roychoudhury, Tippins, and Scantlebury (1995) found that science instruction was generally not connected to students' prior knowledge nor was it relevant to students' everyday lives.

Numerous studies have shown over time that the majority of preservice elementary education majors have negative attitudes toward science (Shrigley, 1974; Morrisey, 1981; Westerback, 1982; Feistritzer & Boyer, 1983; Pedersen & McCurdy, 1992). Of considerable concern is that teachers with negative attitudes toward science can, through their own actions, pass this attitude on to students in their classes (Stolberg, 1969). Ramey-Gassert and Schroyer (1992) have summarized numerous studies concluding that elementary teachers poor self- efficacy has resulted in a science anxiety and that poor attitudes toward science result in an unwillingness or hesitancy to spend any time teaching science. Lucas and Dooley (1982) inferred that poor attitudes toward science can be traced back to the individual's own experiences at school. This assumption was recently validated in a study where autobiographies of 56 preservice elementary teachers were analyzed. The study concluded that "the dominion of text-based science education in the schooling of the preservice teachers and its negative association with experiences in science" was the leading cause of poor attitudes among the participants in the study (Talsma, 1996).

As a result of such research regarding what is and what is not being taught in the schools and more specifically in the elementary classrooms, it is no wonder that the recent reform efforts are underway. The question now becomes whether the reform movements are having any impact on the way science instruction occurs in the content areas, in the teacher preparation programs, and in the public schools.

Science is a process of understanding and exploring the world in which we live. The recently released National Science Education Standards (NRC, 1996) advocate that "Learning science is something that students do, not something that is done to them" (p. 20). The standards also state that "since science content increases and changes, a teacher's understanding in science must keep pace" (p.57). The National Standards go even further to suggest how teachers and prospective teachers should learn and keep pace with science: "Prospective and practicing teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop understanding" (p.60).

The *National Science Education Standards* (NRC, 1996) employ science content as only one part of several facets of science instruction. The standards also equally encourage the process of doing science along with history, philosophy, technology, connections of unifying themes in science, and a personal and social perspective in science with the three basic content areas of life, physical and earth science.

Biology 295, the focus of this research, has provided an experience for prospective teachers which allows them to learn science through situations and activities that are similar to the situations that elementary students will have in order to develop scientific understanding of both the content and process of science. The study conducted for this research has affirmed the findings of past researchers. Furthermore, this study has identified, through thorough analysis of the experiences of the six participants, some striking similarities regarding the hurdles and levels of learning that participants experienced and overcame as they participated in Biology 295.

Each participant came into the course with different backgrounds and experiences in growing up and in learning science. The in-depth case studies reveal similarities and differences in the variety of learning situations of each of the participants throughout the Biology 295 course as denoted in Table 3. Each of the participants had learned biology and had kept a good record in their journal of the concepts. Each of the participants made sense of the "new knowledge" through their prior experiences, whether it was growing up on a farm or relating it to activities and experiences encountered in formal and informal science learning situations. Each student had a philosophical progression from which they began with an idea of how science could be taught and learned in their future classroom to a mature vision and plan of how they would teach science in their future classroom. However, probably the most significant similarity surfaced when all six cases were compared and the experiences thoroughly analyzed.

(Insert Table 3 here)

Table 3: Summary of Demographic & Background Information of Participants.

Name	Classification	Town size	Age/ yr	Birth order	Prior science experience
Jenny Case #4	science smart	mid size urban	21 soph	oldest of 4	mixed school experience.
Samantha Case #2	science smart	rural	21 soph	oldest of 3	pretty good school experiences and growing up on farm
Elly Case #1	science savvy	large urban	21 soph	oldest of 4	mixed school experiences
Natali Case #6	science savvy	rural	19 frsh	youngest of 4	neutral or indifferent school experiences. Dad was science teacher.
Maggie Case #3	science shy	mid size urban	40 soph	older middle of 5	no real experience - none remembered. Perceived as negative.
Elizabeth Case #5	science shy	large urban	21 senr	youngest of 7	bad school experience

Each of the participants went through five progressional stages as they experienced Biology 295. Upon further analysis, and based upon Merriam's (1988) recommendation that case studies should lead to the generation of a theory, the following substantive theory holds for the six participants studied in depth and is thought to hold for the majority of students who experience Biology 295.

The substantive theory suggested here states that preservice elementary education majors encounter five hurdles, or stages, as they experience Biology 295: 1) reservations and hesitations or the anxiety stage, 2) awareness / enjoyment stage, 3) intrinsic shift, 4) rapid building of self confidence and self efficacy, and 5) empowerment. A holistic picture of the reflections encountered in each stage of the theory is depicted in Table 4. Table four helps the reader see in a holistic manner the participants and their progressions. Upon further analysis it is interesting to explore the patterns which emerge from looking at the holistic table along with the different data sources.

(Insert Table 4 here)

Table 4: Overview of participant stages and reflections in the substantive theory.

Name	Hesitation/ Reservation	Awareness & Enjoyment	Intrinsic Shift	Confidence / efficacy	Empowerment
Jenny	Pre Interview 1/9/95 (1)	1/30/95 (4) 2/10/95 (9) 2/13/95 (10) 2/23/95 (22)	2/25/95 (25) 3/2/95 (26) 3/9/95 (40)	3/30/95 (46) 4/6/95 (66) 4/13/95 (75)	5/1/95 Final Journal Entry (FJE) 5/1/95 (82) End note Post interview
Samantha	Pre Interview 1/9/95 (1)	1/14/95 (3) 1/16/95 (7) 1/19/95 (8)	3/9/95 (23) 3/9/95 (25)	4/6/95 (31) 5/1/95 (37)	5/1/95 (FJE) Post interview
Elly	Pre Interview 1/12/95 (1)	1/13/95 (4) 1/19/95 (8) 1/26/95 (12)	2/23/95 (31) 3/7/95 (37)	3/13/95 (40) 4/24/95 (50)	5/1/95 (FJE) Post interview Artifact
Natalie	Pre Interview 1/9/95 (1)	1/12/95 (2) 1/16/95 (3) 1/19/95 (6)	3/2/95 (35)	4/6/95 (47) 4/13/95 (50)	5/1/95 (54) (FJE) Post interview
Maggie	Pre Interview 1/9/95 (1)	1/13/95 (3) 1/20/95 (7)	2/9/95 (20) 3/9/95 (37)	2/28/95 (34) 3/16/95 (44) 5/1/95 (58)	5/1/95 (FJE) Post interview
Elizabeth	Pre Interview 1/9/95 (1)	1/12/95 (3) 1/20/95 (6) 1/20/95 (7) 1/26/95 (11)	3/9/95 (48) 3/9/95 (49)	3/9/95 (49) 4/6/95 (57) 4/27/95 (69)	5/1/95 (72) (FJE) Post interview

Stage one: Hesitations and reservations

In stage one, hesitations and reservations (anxiety), each of the participants clearly stated their reservations in both the pre interview and again after the initial thirty minute introduction meeting on the first Monday lecture session. This only seems reasonable in that most students experience some reservation and anxiety before and on the first day of class. The anxiety, as stated previously, is usually due to the negative experiences that the preservice elementary teachers had priory experienced in learning science in formal settings. It is interesting to note that the participants in this study had various experiences before entering the Biology 295 course.

Elly and Jenny both remembered positive science experiences in elementary school. Samantha, Elizabeth, and Natali all remembered elementary science as basically "text book stuff" and they all conveyed that "they really didn't learn anything." Maggie didn't recall any elementary science at all. None of the participants equated a real dislike for the "text book stuff" they experienced during the elementary years; however, the most enjoyable experiences related to the elementary years were invariably connected to activities where the students were actively engaged in what they were doing. Elly mentioned her outdoor leadership camp where she recalled many "science activities relating to nature." Jenny mentioned her Saturday science camp at UNL where there were "tons of hands-on activities." Natali only remembered a "nature walk" with no details. It is also interesting to note that all the participants related their most negative experiences with science during their high school years. This also seems reasonable as the high school experiences, besides college science courses, were the most recent experiences in the participants memory.

Stage two: Awareness / enjoyment stage

After overcoming the initial hurdle of the anxieties, the preservice teachers spent the majority of their time over the next few weeks of journal entries sharing their enjoyment and enthusiasm for learning science, in some cases for the very first time. During this second stage, there were numerous journal entries reflecting the awareness and especially the enjoyment of doing science. Table 4 only displays the most significant journal entries where awareness and enthusiasm were the primary focus of the reflection. The interesting pattern that emerges in this section is that there was a concentration of these journal entries which stayed consistent for about three weeks. The journal entries during this time displayed some interesting characteristics. The words fun, wow, big +, exciting, great, and I really liked, were written with expression. The words were usually capitalized and written in bright colors. In addition, many exclamation points were used to emphasize the enjoyment factor during this time.

An interesting pattern that emerges here is that all of the participants experienced this enjoyment during the same period of time; however, Jenny was a late bloomer. Jenny was science smart and although she enjoyed the labs, her traditional experiences with science somehow seemed to dampen her initial ability to communicate her enthusiasm and enjoyment in her journal. Jenny's reflections about the first few labs were quite rigid and explored only the content and processes that she learned in class. Although Jenny obviously enjoyed the initial labs as noticed from observations, she didn't begin to communicate her enjoyment until about two weeks later than the rest.

Journal entries from all of the participants continued to mention the enjoyment of doing science throughout the entire semester; however, enjoyment and "fun" were no longer the primary focus issue in the reflections after this time.

Stage three: Intrinsic shift

Stage three or the intrinsic shift was usually a result of the enjoyment combined with the accumulating confidence and realization that the activities done in Biology 295 were actual activities that could be done in the elementary classroom. There came a time when the learning was no longer for the teacher, but for the individual and her future classroom. This shift came at approximately the same time for each of the participants and centered around three events in the class (These events were discussed in detail earlier). The first event consisted of the assigned readings that the students were to read and reflect upon. The second was the Elodea lab where a prolonged amount of time was allotted for the study of photosynthesis in the aquatic plant. The third event was the midterm science fair project/presentation which resulted in a self reflection of the assignment and overall progress in the course up to that time.

The articles allow the students to think seriously about the philosophy toward the teaching and learning of science that they have been experiencing in Biology 295. The photosynthesis and Elodea help the students to realize that they must do their part in learning and not accepting just the "easy answer." Finally, the science fair project allows the students to take both the philosophy and knowledge of learning up to that time and express it in their own experiment. In combination with the enjoyment of science and this application of science that is very personalized, but designed for success, the preservice teachers make the transition from extrinsic motivation to being intrinsically motivated to learn and to do quality work as it has a purpose for their future careers.

Stage four: Rapid building of self confidence and self efficacy

Once the intrinsic shift has taken place the fourth stage of rapid growth of self-confidence and self-efficacy takes place. The participants have been developing confidence and efficacy in their abilities both in learning and teaching science since the beginning of the course. However, like stage two, there seemed to be a concentration of reflections ranging from just after midterm to the last week or so in class that focused on confidence and efficacy. In each of the participants reflections there were numerous statements of how for the first time they had "really understood" a topic or concept and that with this understanding they could really "teach it for the first time." Table 4 only shows the most significant reflections for each of the participants in this area. Strikingly, the majority of the reflections appear with the onset of the cell biology unit.

In Biology 295 the emphasis is not on the terminology, but rather the process by which things do what they do. The students identify with both the process and the philosophy and feel confidence in learning about abstract processes which for many is the first time that any of the processes and terminology has made any sense. Each of the participants wrote reflections communicating this confidence regarding the methodology used to teach about cells. Elly, science savvy, wrote, "In less than one hour on a Thursday night in Henzlik, I suddenly UNDERSTOOD AND APPRECIATED material that had definitely been offered to me before." Samantha, science smart wrote, "This lab has been so rewarding to me because I have learned more on the cell, how it works, organelles of it and what it effects, than I have ever learned in high school or college until now." Maggie, science shy, wrote, "I really learned a lot about the cell. I was able to realize the individual parts of the cell, the way it runs (or lives) and the function of each part. Doing a lesson like this enables ease in understanding and retaining more from the activity." Jenny, Science smart, wrote, "For the first time EVER I am beginning to understand the cell. It was always handed to me before and I was expected to know it - now I can actually begin to understand because I have something to connect it to!" Elizabeth, science shy, wrote, "This was a great connection! I was able to understand what a cell does. We knew what a city looked like, a vision and we knew the functions each part played. . . .There was so much that I learned through acting out the parts of the cell." Natali, science savvy, wrote, "Tonite I learned so much about how a cell is comprised. . . I will probably never forget IP on MAT [stages of mitosis] after decorating the cookies."

The reflections to the cell biology lab are only a few relating the confidence and learning that took place during the unit. The gain in confidence and efficacy about teaching and learning science peaked at the end of the semester and resulting in a new stage.

Stage Five: Empowerment

Stage five is the empowerment stage. The participants in this study have progressed through the stages of anxiety, awareness and enjoyment, intrinsic motivation, and rapid growth in self-confidence and self-efficacy, all of which are part of the definition of empowerment. The empowerment stage in Biology 295 is a stage where the preservice elementary education majors have rather full confidence in themselves and their abilities to actually teach science in their future classrooms. All of the students conveyed their attainment of this stage usually in their final journal reflection and then again in the final interview.

The participants explained how they were able to take the lessons to their practica or other learning environments with children, modify the activity so that it was appropriate for the students in their given situations, teach the concept in a hands-on inquiry manner, and watch the whole process of learning and enjoyment of doing science begin in the eyes of their students. The feeling of being enabled to do science truly becomes empowerment as the preservice teachers teach with confidence and passion and then pass it on to their students. It is interesting to note that the practicum alignment with the Biology 295 course was incidental, but proved to be the major key to the empowerment stage. This only adds to the validity of the argument that one really doesn't learn something until the theory has been put into practice, in this case by teaching it.

Conclusions

In essence, Biology 295 creates an atmosphere for learning science where preservice teachers can capitalize upon their given strengths and learn science in such a way that the preservice teachers then become advocates of science in the schools, a process that probably wouldn't have happened had these preservice teachers taken the "science for the masses" courses where the negative and stereotypical view of teaching and learning science prevail.

Piel and Green (1992) have reported that due to the recent emphasis to improve preservice elementary education majors' science understandings many universities are simply requiring more science courses as prerequisite to entering the professional sequences. In the same study Piel and Green (1992) came to the conclusion that "in spite of highly visible recommendations for more extensive academic course work, results indicate the impracticality of addressing teacher competence through added course work before appropriate attitude adjustment processes have been planned or implemented." The same conclusion was made by Talsma (1996) in her recent study of preservice teachers.

It is important for teacher preparation institutions to recognize that by the time preservice elementary education majors take their science methods course (s) their previous attitudes whether negative or indifferent have been reinforced by the traditional college courses which they have already taken. It is no wonder that so much time in methods courses must be spent initially in convincing the preservice teachers that science is intrinsically interesting.

Based upon the findings presented in this study and related theory of prospective elementary teacher's progression in Biology 295 from anxiety to empowerment in the teaching of science there is no longer any valid justification in assigning "just more content courses." If preservice elementary education majors are to learn science and become science advocates in their future schools, they must first learn to enjoy science and become more confident in their ability to teach science. Thus, one could reasonably conclude that courses should be developed in collaboration with the content areas which replace the general education requirements and yet teach content and pedagogy to these future teachers simultaneously.

This study demonstrated a successful alternative in the learning of content science. Biology 295 has allowed for content and process to be taught simultaneously in a learning environment which enhances preservice teacher's attitudes toward science. This study has theorized the hurdles that preservice teachers overcome in learning content science in order to achieve a positive attitude and confidence toward the subject. This will empower them to teach science in a positive and exciting way so that their future students will not have to overcome the traditional fears and views of science that their teachers may have passed on or may have encountered learning science in a more traditional environment.

Hands-on "type" classes are emerging in colleges and universities across the nation. Numerous funding sources advocate and finance the development of such courses and programs. In a recent study, Wylo (1993) followed recent graduates of elementary education who had experienced a course similar to Biology 295 into their first career teaching assignments. Wylo found that in all of the 38 students surveyed the positive attitudes acquired in the program persisted over time.

Further research in the validation of the hurdles in learning that preservice elementary education majors encounter as they study science in alternative science courses as well as the long term effects of such courses on professional practice seems to be relevant. Although one study has shown that science instruction improves in the field with such a course, further research and replication studies should be done to explore the long term effects of such theories and programs in practice both inside and outside of the science education community.

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