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Developing an interest in science: background experiences of preservice elementary teachers

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Аннотация

Research on playfulness, science, and creativity suggests that there is a connection between having positive background experiences with science and the development of interest in science. However, there is little empirical research on where, how, and when teachers' interests in science develop. The purpose of this research was to explore connections between preservice elementary teachers' background science experiences and interest in science. Subjects were 53 preservice teachers in two sections of a science methods course. The data were collected by administering a self-report Science Background Experiences Survey. Students with low and high initial interest in science were significantly different on remembering about their elementary school science and involvement in non-school science activities including science related field trips, play and exploration.

Ключевые слова: informal science experiences, interest, school science experiences

Introduction

Educational philosopher Dewey (1913/1979), psychologists Krapp, Hidi, and Renninger (1992), and the National Science Education Standards (NRC, 1996) describe effective teachers as interested in their subject and demonstrating enthusiasm for teaching the course content. How does teacher interest develop, especially interest in science? Do schooling and play experiences motivate teachers to be more interested in science? The purpose of this study is to ascertain the connection between the quality and type of background science experiences and pre service teachers' interest in science. In other words, what sorts of experiences affect the development of interest in science?

Theoretical Framework

Several theories supporting the motivational value of interest and the role of background experiences in developing interest influenced this research. These theories are Dewey's (1913/1979) theory of the relationship between interest and effort, Glasser's (1998) choice theory, Csikszentmihalyi's (1990) construct of flow, and Piaget's ideas on disequilibrium. Added to these is a body of research on the role of interest in learning and in behavior by psychologists Krapp, Hidi, and Renninger (1992) and Deci, (1992, 1995). According to Dewey (1913/1979), curiosity is innate in children. Becoming interested in a particular subject is a process that often begins in childhood play. Unfortunately, as children pass through schooling, their natural desire to inquire is gradually diminished, largely because of the prevalence of traditional, didactic, teacher-centered instruction. However, according to his theory of interest, childhood interests often influence adulthood interests as people grow older.

Research findings indicate that when people are interested in something, they become more attentive and alert (Krapp, Hidi, & Renninger, 1992). This leads to a level of absorption called flow (Csikszentmihalyi, 1990). Flow is the "state of mind when consciousness is harmoniously ordered, where people want to pursue whatever they are doing for its own sake’’ (p.6). Flow activities are not static. Neither boredom nor anxieties are positive experiences. Flow activities involve greater challenges, and demand greater skills. Flow activities have a dynamic feature which leads to growth and discovery. Scientists and inventors have identified flow as part of the process of scientific discovery (Csikszentmihalyi, 1996).

Working within the conceptual framework of Dewey (1913/1979), Krapp (2004) espoused creation of learning environments in which students actively interact with materials to reach an actualized state called situational interest, eventually developing into an enduring and more diffuse state, called individual interest. Krapp (2004) hypothesizes that transition from situational to individual interest can occur only if both feeling-related experiences and cognitively represented factors are experienced together and positively. Glasser (1998) describes fun and freedom to choose as basic human needs, suggesting that students in classrooms where science is fim and where there is student input might develop more interest in science.

According to Piaget (1964/2003), children are naturally curious and learn through actively exploring their environment. Across the life span, according to Piaget, exposure to new experiences throw existing ideas into disequilibrium and drive people to make sense out of new information. Piaget's ideas on equilibration suggest a state of disequilibrium is disconcerting and that the learning that occurs when accommodating one's thinking to make sense out of new experiences is satisfying.

Research on Background Experiences

Biographical studies of Albert Einstein, Robert Bums Woodward, Charles Darwin, Richard Feynman and other eminent scientists suggest that rich and playful early childhood experiences with science had an impact on their careers and interest in science (Kegan, 1989; Shepard, 1988; Rothenberg, 2005; Tweney, 1989; Woodward, 1989). Their interests were: playing with physical gadgets, playing with mechanical construction sets, working with electricity, and enjoying experiments that included "messing around." There are a few studies on university professors' development of interest in science and selection of science as a career. Jarrett and Burnley (2007) examined the role of a variety of outdoor and indoor activities on geoscientists' interest in science and found that these informal experiences played an important role in the development of a scientific mindset and the selection of science as a career. Rowsey (1997) examined the influence of schooling on the vocational choice of university professors from various fields of science and ascertained that elementary and middle school teachers had little influence on vocational choice by university professors.

Most of the professors were influenced by parents and other relatives in their career choice and said there was not any particularly influential event in junior or senior high school that impacted their choice to become scientists.

Research indicates that playful engagement with science in childhood and youth influences interest in science. According to Dillon, Franks, and Marolla (1975) children need to be relatively free from testing pressures in schools and have freedom to wonder, explore, and discover in order to develop interest in science. Joyce and Farenga (1999) examined the science perceptions of high ability upper elementary students and ascertained that they had already decided whether they liked or disliked science before the age of nine. These students believed that their early childhood science experiences inside and outside of school played a key role in development of their interest.

Research with a cross-section of adults, as well as research with science majors, confirms the importance of early experiences in the development of interest in science. Falk (2002) surveyed adults over 18 years old on the contribution of non-school sources for learning science and found that science was not exclusively nor even primarily learned in school. The survey results revealed that a significant percentage of science learning occurs from the following, in order of significance: books and magazines (not for school), life experiences, TV and cable, school science courses, museums and zoos, on the job, family and friends, radio and audiotapes. In a study with undergraduates in a geology research program, Jarrett and Burnley (2005) found that outdoor explorations such as collections, museum visits, LEGO bricks, and other construction toys were important aspects of their childhood experiences. These experiences appeared to be influential for geology undergraduates' interest in science and choice of science as a career.

Three studies using the Relevance of Science Education (ROSE) survey (Kim & Song, 2009; Lavonen, Byman, Uitto, Juuti & Meisalo, 2008; Trumper, 2006) also suggest a connection between background experiences and personal interest in science. Among Israeli 9th graders, opinions about out-of-school science experiences and quality of science classes were predictors of interest in physics (Trumper, 2006). In Finland, experiences with science and technology hobby activities predicted interest in how things work, explosive and poisonous objects, and science and technology in everyday life (Lavonen, et al., 2008). In the same study, experiences of nature and making collections predicted interest in astronomy and cosmology, environmental issues, human phenomena, and physics and chemistry in the environment. Surveying students in Japan, Kim and Song (2009) found that interest in science is associated with intrinsic attitudes and experiences rather than stemming from the importance of science for society, considered an extrinsic motivator in this study.

Most of the research on interest and background science experiences has been focused on scientists or on students in science courses, but there are a few studies conducted in teacher preparation programs. De Laat and Watters (1995) studied the origins and changes in preservice teachers' science teaching self-efficacy and found that teachers with high personal teaching self-efficacy had been interested in science for a long time and had a relatively strong background of formal and informal science experiences. A study of preservice elementary teachers (Sampson, 1992) examined their previous school and life experiences and attitudes toward science and science teaching. Most of the pre service teachers in the study claimed that their non-school experiences stimulated their curiosity more than their science classes in school. In another study using regression analysis, Jarrett (1999) found that whether elementary school science was memorable was the best predictor of interest in science, followed by informal science experiences. This study addresses the following research questions: What science background experiences (school, home, and informal education) do preservice teachers have? How do those experiences affect interest in science at the beginning of a science methods course?

Method

Participants and Context

Participants in this study were an available sample of undergraduate preservice elementary teachers in the Early Childhood Education Department at an urban southern university in the U.S.A. To be admitted into the Early Childhood Education program they had completed their first two years of university with a minimum grade point average of 2.75 (on a 4 point scale) and were recommended by an interview team. They were students in two sections of a science methods course during the spring semester 2006. The preservice teachers were second semester juniors in the undergraduate program. The program was heavily field-based with school placements for different methods courses each semester in schools having various levels of partnership with the university. Following a developmental sequence, preservice teachers were placed in pre-K and Kindergarten classrooms and eventually were placed in grades four or five classrooms. They were in schools two days a week, placed with an experienced cooperating teacher, and observed at regular intervals by a university supervisor. They also took classes on campus two days a week. They had taken at least two semesters of laboratory-based science content courses before being admitted to the early childhood education program. During the semester in which they participated in the research, they were in a section of a science methods course taught either by the first author (a doctoral student at that time) or by another doctoral student. All course members, a total of 53 participants, signed informed consent letters, agreeing to participate in this research.

Data Sources

Interest in Science Question

In class at the beginning of the semester, students answered a survey on attitude toward science adapted from a survey by Jarrett (1999). On the question used in this study, test-retest agreement was found in the earlier study to be: 71% identical answers with the other 29% answers varying by one point. The question was:

What is your overall interest in science?
(Low) 1 2 3 4 5 (High)

The purpose of this question was to categorize students so that high interest and low interest students could be compared on background experiences. High interest students are those who gave a response of 4 or 5, and low interest students are those who gave a negative or neutral response (1-3).

Science Background Experiences Survey

The purpose of this survey, administered in class during the science methods course, was to identify formal and informal background experiences of students that might predict interest in science. This instrument was adapted by authors from questions used in a study by Jarrett (1999), with two questions adapted from Sampson (1992). The survey consists primarily of items on a five point Likert scale in which students rated their background experiences in elementary school, middle/junior high school, high school, and college/university. The students were asked to rate their experience on the following dimensions: fun, interesting, hands-on, student input, learning, and emphasis on understanding. At high school and university levels, the students were to identify their best science course, rate their overall enjoyment of that course, and say whether that course was typical. They then rated that course on the above dimensions. The assumption was that having at least one good course might be influential, even if other experiences are negative or neutral. Students also rated parent support and non-school experiences and identified play and recreational activities important in their childhood or youth. Although the survey has face validity, the complexity of the survey and the variety of questions precluded calculation of reliability. The Science Background Experiences Survey can be found in the Appendix.

Data Analyses

The data were entered into SPSS and analyzed using independent samples t-tests where the sample size permitted and descriptive statistics. Separate analyses were computed for each question except for where data were combined.

Results

Students' background science experiences are described and compared according to whether they had low or high interest in science. A frequency count revealed that 22 students (42 %) had low interest in science and 31 (58 %) students had high interest in science. Answers to the Science Background Experiences Survey are categorized according to low versus high interest in science and are discussed by question, with Questions 1-5 relating to school experiences and Questions 6 - 9 relating to non-school experiences. The school science experiences included: (a) elementary science course experiences and best year science experiences, and (b) best science course experiences in middle school, high school, and university, identified as typical or non-typical. The rationale for these questions was to determine whether participants had at least one good experience within that school level and whether that experience was representative of their overall science experience. The non-school science experiences included: parental support, school field trips, informal science activities, and play experiences related to science.

Elementary School Science Experiences

In Question 1, the preservice teachers were asked whether they could remember elementary school science. If they could remember anything about elementary school science they were asked to describe their best year in elementary school science on the following dimensions: fun, interesting, hands-on, level of students input, how much they learned, and emphasis on understanding. A frequency count of students who could and could not remember elementary school science, organized by low and high interest in science indicated that 74.2% of 31 high interest participants (N = 23) could remember elementary school science compared to 36.4% of the 22 low interest participants (N - 8). Remembering about elementary school science, coded dichotomously (0 = cannot remember anything; 1 = can remember about elementary school science), was analyzed to compare low and high interest students using an independent samples t- test. There was a significant difference between the low interest group (M = .36; SD = .49) and the high interest group (M = .74; SD =.44), $t(51) = 2.9, p < .005$).

Of those who remembered elementary school science (second part of Question 1), there was no difference according to general enjoyment of science. Both interest low and high interest groups had slightly above average enjoyment of science in elementary school (Mean = 3.78). Those who could remember elementary school science described their best year as above neutral for fun, interesting, hands-on, and learning. However, the means for student input and understanding emphasis were neutral or lower than neutral, indicating that even though there were some good experiences, science was teacher-dominated, with memorization rather than understanding emphasized. Only eight low interest students remembered science and therefore could answer the questions, precluding statistical comparisons. Table 1 shows the means and standard deviations forthose participants who could remember science during elementary school.

Best Science Course Experiences in Middle School through University>

Questions 2, 3, and 5 assessed pre service teachers' ratings of science coursework in middle school through university. They rated their enjoyment of their best course and then rated it on the six descriptors: fun, interesting, hands-on, student input, learning, and u nderstanding emphasis. Also, participants were to describe how typical this was of their science experiences at each level of schooling and give any further comments. The means for those with low and high interest are found in Table 2.

Table 1. Means and standard deviations of best year experiences in elementary school science for those who remembered science

	Low interest			High interest		
	N	Mean	SD	N	Mean	SD
Enjoyment of elementary school science	8	3.75	.71	23	3.78	.95
Best year in elementary school science						
Fun	8	3.78	.99	23	3.95	1.04
Interesting	8	3.87	.99	23	3.95	1.14
Hands-on	7	3.28	1.11	23	3.39	1.33
Student input	8	3.00	1.06	23	2.91	1.27
Learning	8	4.00	.53	23	3.69	.97
Emphasis on understanding	8	2.75	1.16	23	2.86	1.14

Middle School

With the exception of the rating of student input by the low interest group, middle school best course ratings were a bit above neutral, Independent samples t-test found only one significant difference in middle school ratings between low interest and high interest groups, on student input, t (47) = 2.07, p <04) with low interest mean = 2.63 and high interest mean = 3.30.

High School

Questions asked about high school experiences concerned: favorite science subject, description of best science class, and number of Advanced Placement classes taken. Advanced Placement classes can be used for college credit, if the student tests well. In answer to best science course in high school for both low and high interest groups, biology was considered the best course, followed by chemistry and physics. Only about 10% of the participants took advanced placement courses in high school. As with earlier questions, participants were asked to describe their best science course on the same dimensions. Independent samples t-tests found no significant difference on enjoyment or on any of the six of the descriptors. The means for enjoyment and the course descriptors indicated that for both groups the course was enjoyable and above neutral on all descriptors.

College /University

To describe college/university science course experiences the students were told to identify each college/university science course taken and to rank the two courses they liked best in order of preference. Biology was the most popular course among high interest students and geology was the most popular course among the low interest students. The top three best science courses were almost the same for both low and high interest groups. The top three best science courses for the low interest group were biology, geology, and a tie between astronomy and physics. The top three best science courses for high interest group were biology, astronomy, and geology. One of the students in the high interest group did not like any of the courses he/she took in college/university. To determine the qualities of the best science experience of the low and high interest students in college/university, means and standard deviations were computed, and independent samples t-tests compared low and high interest students. There were no significant differences between high interest and low interest participants on any of the descriptors. In general, the means fell around neutral (3) for both groups of students.

Table 2. Means and standard deviations of low interest and high interest participants on best science experience in middle school, high School, and university

	Low Interest			High Interest		
	N	Mean	SD	N	Mean	SD
Middle School						
Enjoyment of course	17	3.88	.69	30	3.66	.99
Fun	19	3.78	.91	30	3.70	1.14
Interesting	19	3.73	1.04	30	3.70	1.26
Hands-on	19	3.10	1.24	30	3.43	1.25
Student input	19	2.63	.95	30	3.30	1.17
Learning	19	3.84	.95	30	3.43	1.19
Understanding emphasis	19	3.10	1.19	30	3.06	1.17
High School						
Enjoyment of the course	22	4.04	.95	31	4.38	.84
Fun	22	3.77	1.19	31	4.35	.87
Interesting	22	3.81	1.22	31	4.03	1.19
Hands-on	20	4.00	.917	31	3.87	1.38
Student input	22	3.09	1.30	31	3.45	1.36
Learning	21	4.14	1.15	31	4.06	.99
Understanding emphasis	22	3.27	1.35	31	3.54	1.23
University						
Enjoyment of the course	21	3.33	1.27	30	3.50	1.30
Fun	22	3.00	1.27	30	3.20	1.34
Interesting	22	3.00	1.41	30	3.23	1.54
Hands-on	22	3.31	1.24	30	2.73	1.50
Student input	22	2.59	1.09	30	2.80	1.51
Learning	22	3.45	1.05	30	3.23	1.35
Understanding emphasis	22	2.95	1.29	30	2.76	1.38

Best Courses Ratings According to How Typical

Combining the ratings on the best course descriptors with whether or not this course was typical and using a formula developed by Bulunuz (2007), student experiences were categorized as: typical and negative, typical and neutral, not typical but positive, and typical and positive. The following table shows the frequencies of the low and high interest students in their middle school, high school, and university science experiences. In this table, as in the following tables that report quality of science experience, the number of subjects does not add up to the total number of participants because a few participants did not answer whether their experiences were typical.

For the low interest group there was not one dominant type of experience in middle school. For the high interest group, the dominant type of experiences was neutral (59%) with that experience being typical. When rating their best course, 54% of the low interest and 34% of the high interest students had a good experience. In high school, the experiences were reversed with 61% of the low interest and 71% of the high interest having a positive experience in their best class. At the university level, the experiences for both low and high interest students were more negative with only 31% of the low interest and 32% of the high interest students having a positive experience, at least in their best course. Across school levels, typical positive experiences were experienced by 11% to 35.5% of the students with more typical and positive experiences in high school than in middle school or university.

Table 3. Percentage of low and high interest participants by quality of science experience in middle school, high school, and college/university

Type of experience	Low Interest (N = 18)	High Interest (N = 31)
Middle School/junior high school		
Typical Negative	23%	7%
Typical Neutral	23%	59%
Not Typical Positive	23%	14%
Typical Positive	31%	20%
High School		
Typical Negative	22%	13%
Typical Neutral	17%	16%
Not Typical Positive	33%	35.5%
Typical Positive	28%	35.5%
College/University		
Typical Negative	25%	36%
Typical Neutral	44%	32%
Not Typical Positive	19%	21%
Typical Positive	12%	11%

Science Fairs

The preservice teachers were asked what experiences they had participating in science fairs The overall frequency of science fair participation indicates that 76% of low interest students and 58% of the high interest students had participated in at least one science fair. About 30% of both low and high interest students participated in science fair project more than one year and approximately 10% of both groups had gone on to regional or state fairs.

Non-school Science Activities and Experiences.

To further investigate the difference between low and high interest students, several additional questions (questions 6-8) were asked on the survey. The results of the following three questions are found in Table 4. Again, low and high interest participants are compared.

In addition to the above questions, participants were asked about their play and informal learning experiences, Question 9. The list of activities (see Appendix) was made up of (a) activities mentioned by scientists and science majors in previous studies (Bayer Corporation, 1988; Jarrett & Burnley, 2003; Jarrett & Burnley, 2007), (b) activities with obvious connections to science or engineering, and (c) non-science items as fillers (e.g., playing school or visiting a history museum). Those considered science or engineering related are listed in Table 5.

The preservice teachers were asked to put a a/ before the ones that were part of their childhood/youth and a second a/ before the ones that were an important part of their childhood/youth. They could add any other childhood/youth activities to the bottom. The frequencies and percentages of participants who checked the above science-related experiences at least once are given in Table 5. They are listed in order from most frequently checked to least frequently checked.

The above science related activities that had at least one check were tallied and formed the variable, all science activities. The science related activities with two checks were tallied and formed the variable, important childhood/youth science activities. A third variable included all the science activities checked, with those checked twice weighted double. This variable, called weighted all activities, was calculated by tallying all the checkmarks for science related activities. Table 6 shows descriptive statistics for these three variables.

Table 4. Means and standard deviations of rating of outside of classroom science influences

	Low Interest			High Interest		
	N	Mean	SD	N	Mean	SD
Parents were supportive	22	3.22	1.37	31	3.61	1.35
School field trips were important	22	3.18	1.25	31	3.41	1.25
Non-school experiences more important than science classes	22	3.45	1.43	31	4.03	1.19

Table 5. Frequencies and percentages of non-school important childhood/youth science activities

Non-school science Activities	N	%
Visit to zoos, nature centers, aquaria	48	92.3
Playing in sand	46	88.5
LEGO bricks or LEGO robotics	43	82.7
Exploring the outdoors	40	76.9
Care of animals	39	75
Building with wooden blocks	37	71.2
Visit to science museum	36	69.2
Play with doctor/nurse kits	36	69.2
TV nature or science programs	34	65.4
Planting in the garden	33	63.5
Taking things apart	32	61.5
Making science collections	30	57.7

Camping	27	51.9
Star gazing	27	51.9
Beach combing	27	51.9
Microscope or telescope	25	48.1
Care of house plants	25	48
Mixing up “kitchen chemicals”	22	42.3
Risky play (making explosive, etc.)	14	26.9
Making models (e.g airplanes, boats)	13	25
Snorkeling or SCUBA diving	11	21.2
Chemistry kit	9	17.3
Computer programming	6	11.5
Science club	6	11.5

Parametric tests, such as t-tests assume that both variables should be measured on an interval or a ratio scale, but are considered robust for ordinal measures. Because the variables important childhood/youth science activities, all science related activities, and weighted all science activities, are counts for the number of activities, informal science experiences and activities were recoded into four categories with the highest and lowest number of mentioned activities divided into equal intervals. Important childhood/youth science activities were recoded (1 = fewer than four activities; 2 = five to nine activities; 3 = ten to 14 activities; 4 = 15 to 19 activities). The all science activities were recoded (1 = fewer than six; 2 - 7 to 13; 3 - 14 to 20, 4 - 21 to 27). The weighted all science activities variable was recoded (1= 0 to 9; 2 = 10 to 19; 3 - 20 to 29; 4 = 30 to 39). Using the recoded variables, high and low interest participants were significantly different on two of the above variables, important childhood/youth science activities, $t(51) = 3.59$, $p < 001$ and weighted all science activities, $t(51) = 2.83$, $p < 01$. High interest students had a stronger background in informal science activities than low interest students.

Table 6. Means and standard deviations of non-classroom influences on interest in science

	Low Interest			High Interest		
	N	Mean	SD	N	Mean	SD
Important childhood /youth science activities	22	2.91	2.11	31	6.87	4.38
All science activities	22	10.95	6.01	31	13.94	4.35
Weighted all science activities	22	13.86	7.31	31	20.81	7.82

Conclusions and Implications

This study has a number of limitations that restrict generalizability. Results apply only to elementary school teachers. The sample was small and consisted of self-contained classes. The surveys relied on participants' memories about their background science experiences. Because many participants had difficulty in remembering their elementary school science experiences, what actually happened in the non-memorable classroom is not known. Further research studies on background experiences could be conducted with current middle school or high school students who might still remember the perhaps boring aspects of elementary school, as well as the more memorable aspects. Additional research could also include interviews with students, parents, and teachers. We also recommend additional research with the Science Background Experiences Survey using larger samples and other populations.

That said, the findings of the study suggest the importance of elementary school science as well as informal science experiences to engender an interest in science. The analysis of background science experiences suggests several important findings. An encouraging finding was that more than half of the preservice elementary teachers (58%) came to the science methods course with high interest in science. Only two school-related background variables distinguished between low and high interest groups. Students with low and high initial interest in science were significantly different on remembering about their elementary school science. Most of the low interest students could not remember anything about elementary school science, suggesting that their experiences were simply not memorable. They might not have remembered because they did not have science, they had very little science, or their science experiences were uninteresting. According to Dewey (1916) and Piaget (1964/2003), children learn science by acting on objects and manipulating materials rather than by a process of being told or just reading from books. People tend to remember experiences that are fim, interesting, exciting, and new to them. These results are similar to the findings of Jarrett (1999) with preservice teachers, Bayer Corporation (1998) with scientists, and Joyce and Frenga (1999) with children. All these studies found relationships between the quality of elementary school science experiences and interest in science.

Only one other school experience differentiated between students of low and high interest in science. High interest participants said that they had a greater degree of student input during middle school classes than did low interest participants. This finding would suggest that student input is important for developing interest in science. Student input in science courses means students are not passive recipients of scientific facts, concepts and principles in science class, but are active, both physically and mentally. This importance of student input is consistent with philosophers/child development theorists (Dewey, 1916; Piaget, 1964/2003) and the NSES (1996), who accepted the premise that every student comes to the classroom with different background experiences, and discovery should start with students' curiosities, interests, and experiences that are salient motivators for learning. However, since multiple t-tests had been computed on the various qualities of experience variables, and student input is the only variable showing differences in middle/ secondary or college, there is the possibility that this difference might have occurred by chance.

According to the preservice teachers' ratings of their "best course experience" and whether this was typical of their science courses, many did not have very positive science experiences in middle school and high school. They generally rated their best course between 3 and 4 on a five point scale. For many, this course was better than the other courses, not typical of them. Only 11% took any advanced placement (AP) science classes, and only 10% participated in science fairs beyond their own school level. High school students with aspirations for teaching should be encouraged to take advanced placement classes and engage in their own research leading to science fair recognition. Middle and high school science curricula also should take into account teachers' enjoyment while teaching science. Science curricula should provide guidelines for teachers without restricting their freedom and creativity. Teachers' freedom to design their own curricula may lead to focus on students' questions, curiosities, interest and experiences.

The comparisons of science courses taken from middle/secondary school through college/university indicated that there was not much difference among students by interest level. The dominant "best course" for both low interest and high interest students in both high school and university was biology. Both groups took few advanced placement courses. The ratings of "best courses" appeared to drop between middle/secondary and college/university. In middle/secondary over a third of the students' course ratings showed that they had a good experience that was typical of their coursework. However, at the university level only 11.5% gave similarly high ratings. In their ratings of their "best science course," neutral levels of enjoyment of the course corresponded to neutral ratings on course descriptors of student input, hands-on, and understanding emphasis, suggesting that enjoyment decreased as students had less control over their learning. That is a situation typical of introductory lecture courses with cookbook-type labs. One surprise was that 76% of the low interest participants had had science fair experience compared to 58% of the high interest participants. What is not known is whether participation was required and whether the experience was positive. Further research should examine types of science fair experiences and their effects on interest in science.

Aside from remembering elementary school, what best differentiated between low and high interest students was involvement in non-school science activities, including the number of science activities experienced in early childhood and youth and the number of activities considered an important part of childhood. The most frequently mentioned activities were visits to science museums, nature centers, zoos, and aquaria. Also mentioned frequently were home related activities such as care of animals, planting a garden, play with science kits, making science collections, taking things apart, playing with LEGO bricks and wooden blocks, and watching science programs on TV. Such experiences appear to be more important than formal science courses in distinguishing between low and high interest students. Autobiographical studies of eminent scientists (Kegan, 1989; Shepard, 1988; Tweney, 1989; Woodward,

1989) and research on university science professors (Jarrett & Burnley, 2007; Rowsey, 1997) indicate that out-of-school science activities have a strong influence on selecting science as a career. Also, research with children (Joyce & Farenga, 1999), research with preservice teachers (DeLaat & Watters, 1995; Sampson, 1992), and survey results (Falk, 2002; USA Today, 1994) indicate that informal science experiences are influential in learning and developing interest in science. These out-of-school science experiences are likely to be highly dependent on parental support and encouragement.

One of the implications of this research is that it is important for people to have memorable science experiences in elementary school and involvement in out-of- school science activities in order for them to develop interest in science. These findings have implications for parents, school systems, curriculum developers and teacher preparation programs. Parents should be aware of their own impact in promoting their children's interest in science by doing home-related activities such as experimenting with kitchen chemicals, looking at things under a microscope, taking care of plants or pets, playing with LEGO bricks or LEGO robotics, and making science collections. In order to increase parent awareness, schools can organize family science nights or family science festivals where parents, children and teachers do science activities together and where parents can obtain ideas for science activities they can do with their children using free or inexpensive materials.

Science related community facilities such as science museums, nature centers, zoos, and aquaria are valuable resources for parents and schools. Since such community resources are often expensive, it is important that schools provide field trip opportunities to these sites, increasing budgeted monies or finding corporate sponsors if necessary. These trips are particularly important for children whose parents are unable to afford frequent, expensive out-of-school science experiences for their children. However, not all field trips are expensive. Children can also learn from observing nature on the school yard.

School experiences can also include science clubs, classroom plants and pets, and classroom science museums. Participating in science clubs was the least frequent activity among participants. Schools can support or facilitate these activities by encouraging teachers who are interested in science to organize science clubs. Elementary schools should also be equipped with appropriate science equipment and materials, including LEGO bricks, microscopes, and measuring devices. Some schools have such materials in storage and unavailable to teachers. An answer to the school equipment problem may be to take inventory of specialized items and arrange a check-out system, perhaps from the media center. However, each classroom should have basic science equipment in the classroom (e.g. balances, microscopes, thermometers, magnifying glasses) so students can do ongoing investigations.

The tendency for best class enjoyment ratings and "high and typical" science course ratings to be somewhat lower at the university level than at the middle and high school levels (Tables 2 and 3) implies the need to examine and possibly revise science content courses for preservice elementary teachers at the university level. Ratings of science content courses indicated that there is much emphasis on memorization, little fim, few interesting hands-on science activities, and low student input. Even participants who were interested in science typically did not experience university science in a way they could apply to an inquiry classroom. We recommend that science content courses for teachers be reframed to use inquiry teaching that teachers can model with students.

Although this study must be considered preliminary, the findings are intriguing. The major difference between the preservice teachers who were interested and uninterested in science were memories of elementary school science and quantity and importance of informal science experiences and activities. Methods classes that help teachers develop memorable science lessons and that help them incorporate elements of informal science in the classroom may encourage the development of future generations of teachers interested in science and motivated to make science memorable fortheir students.

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